

# Air Quality Emissions Assessment – Project Kea

✦ Prepared for

South Island Resource Recovery Limited

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## 1.0 Introduction

Babbage Consultants Limited has engaged Pattle Delamore Partners Limited (PDP) to undertake an assessment of the potential air quality effects associated with a proposed Energy to Waste plant (the Proposed Plant or Project Kea) in rural South Canterbury. The Proposed Plant will be owned and operated by South Island Resource Recovery Limited (SIRRL). This assessment is required to support a resource consent application to the Canterbury Regional Council (Environment Canterbury or ECan) for this project.

The Proposed Plant will have the capacity to process 365,000 tonnes of solid waste (SW) per year. The SW will consist of municipal solid waste (MSW) and construction waste (CW). The energy released from the processing will be converted to steam and electricity (via a steam turbine and generator).

SW will initially be delivered to the site by trucks (however, transport by rail is also being considered). The SW will consist of non-recyclable materials (i.e. material going to landfill), and this could include organic waste and non-recyclable fossil fuel derived products. The Proposed Plant will not accept hazardous materials<sup>1</sup> or tyres.

The steam generated by the Proposed Plant will be available as a heat source for local industries. The generated electricity would be fed into the local network and the national grid enabling the Proposed Plant to support local industries first and reduce the current demand for burning fossil fuel (coal). Overall, the production of steam and electricity will:

- ∴ Strengthen the electricity supply to the local network;
- ∴ Provide energy to enable local business expansion; and,
- ∴ Eliminate the current annual one-week shut down period suffered by local businesses due to Transpower maintenance.

The Proposed Plant will utilise the proven best available techniques (BAT) defined by the Industrial Emissions Directive 2010/75/EU to minimise off-site effects.

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<sup>1</sup> Other than those small incidental quantities that may be present in the SW.

## 2.0 Background Information

### 2.1 Site location

The Proposed Plant is located in rural South Canterbury on the corner of Morven Glenavy Road and Carrolls Road. Figure 1 shows the location of the site as a red polygon.

The co-ordinates of the approximate centre of the site are Universal Transverse Mercator (UTM) 508,707 m East (E) and 5,028,725 m South (S), Zone 59S. The site is zoned Rural under the Waimate District Plan. Rural zoning encompasses all the non-residential areas of the district including lakes and rivers.

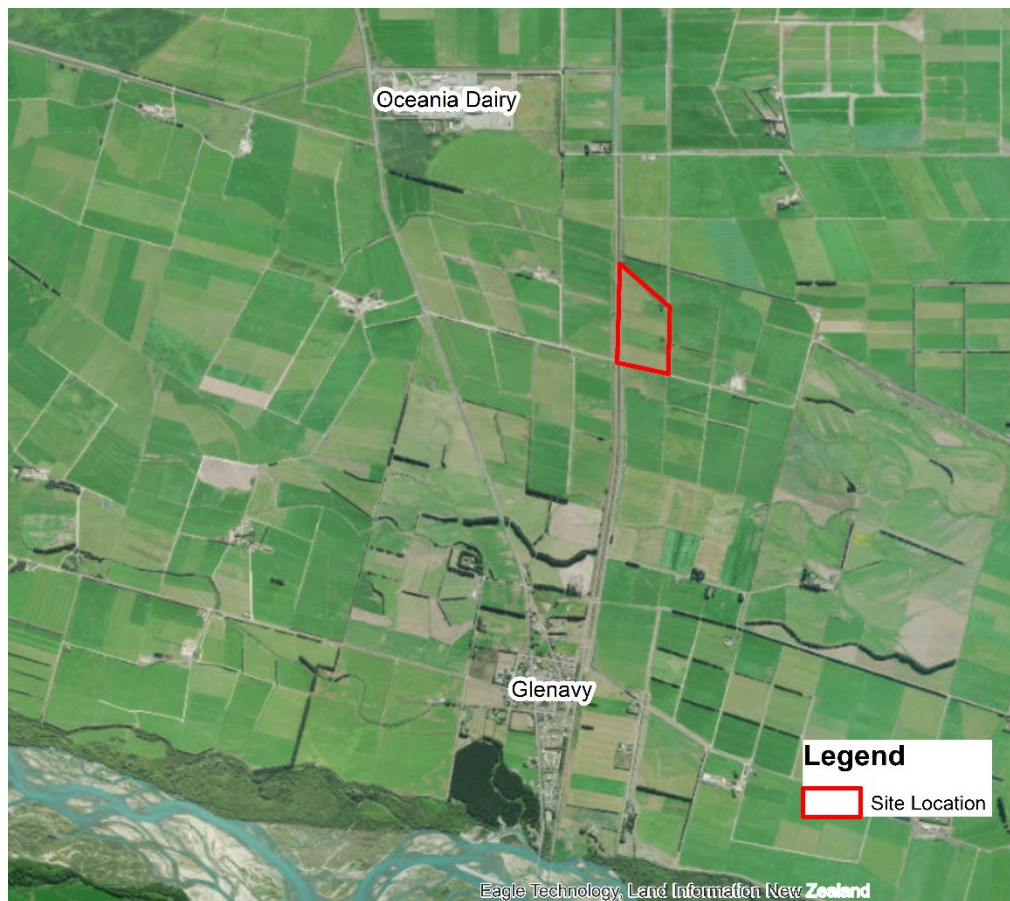


Figure 1: Site Location

### 2.2 Hours of Operation

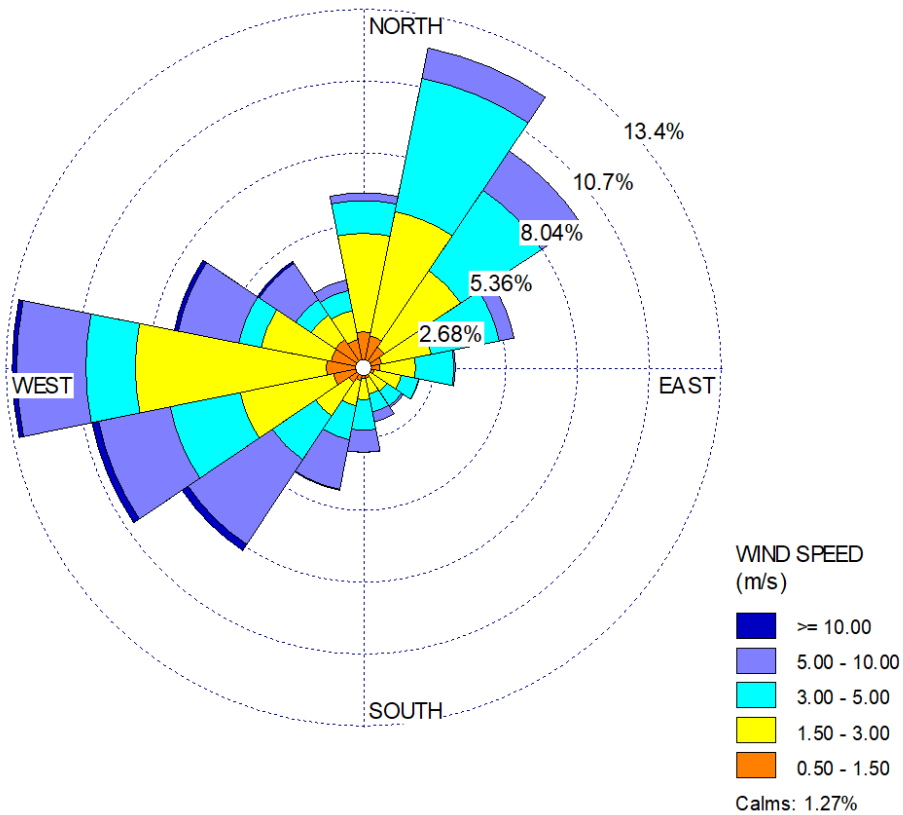
The Proposed Site will operate 24 hours a day, seven days a week.

### 2.3 Meteorology

The topography of the surrounding area can influence wind speed and direction. Therefore, it can significantly affect air pollutant transportation. However, the area around the site is flat and the terrain features will have minimal influence on the winds experienced in this area.

The nearest publicly available meteorological station is located in Waimate. Due to Waimate being located 16 km northwest of the site and located in the lee of the nearby range, it is not considered representative of the winds experienced at the Proposed Site.

The distribution of hourly average wind speeds and directions has been extracted from CALMET for the Proposed Site and is shown in Figure 2. The windrose shows that the predominant winds are from the north northeast and west. This is representative of the winds coming down the Waitaki Valley to the west of the site and the sea breezes coming from the northeast. The distribution frequency of wind speeds has been provided in Table 1. Further meteorological comparisons between the CALMET dataset and Waimate meteorological station has been provided in Appendix A.



**Figure 2: Wind Speed and Wind Direction Distribution for the Proposed Site (CALMET)**



<b>Table 1: Percentage of Wind Speed Frequency Distribution for the Site</b>					
<b>Direction</b>	<b>Wind Speed (m/s)</b>				<b>Total</b>
	<b>0.5 – 1.5</b>	<b>1.5 – 3</b>	<b>3 – 5</b>	<b>5 - 10</b>	
North	1.4	3.7	1.2	0.3	<b>6.6</b>
North northeast	1.2	4.7	5.1	1.1	<b>12.1</b>
Northeast	1.0	3.4	3.6	1.8	<b>9.8</b>
East northeast	0.7	1.9	2.6	0.6	<b>5.8</b>
East	0.6	1.3	1.4	0.1	<b>3.4</b>
East southeast	0.5	1.0	0.7	0.0	<b>2.2</b>
Southeast	0.4	0.7	0.6	0.1	<b>1.8</b>
South southeast	0.4	0.6	0.7	0.4	<b>2.1</b>
South	0.4	0.8	1.1	0.8	<b>3.1</b>
South southwest	0.5	1.0	1.3	1.9	<b>4.7</b>
Southwest	0.7	1.5	1.9	4.1	<b>8.2</b>
West southwest	1.2	3.5	2.7	3.0	<b>10.4</b>
West	1.4	7.1	1.8	2.7	<b>13.0</b>
West northwest	1.3	2.7	0.8	2.5	<b>7.3</b>
Northwest	1.3	1.1	0.7	1.7	<b>4.8</b>
North northwest	1.1	1.1	0.8	0.4	<b>3.4</b>
<b>Sub-total</b>	<b>14.1</b>	<b>36.1</b>	<b>27.0</b>	<b>21.5</b>	<b>98.7</b>
Calms <sup>2</sup>					<b>1.3</b>
<b>Total</b>					<b>100</b>

## 2.4 Sensitive Receptors

A sensitive receptor is defined as a location where people or surroundings may be particularly sensitive to the effects of air pollution e.g. aged care facilities, hospitals, schools, early childhood education centres, marae, cemeteries, residential properties, other cultural facilities and sensitive ecosystems.

<sup>2</sup> Calms are defined as wind speeds less than 0.5 m/s

A desktop study was undertaken and identified a number of dwellings located near the Proposed Plant. As a result, PDP has selected 14 receptors representative of the local community within the area surrounding the proposed plant and three receptors (one each) at the closest towns; Oamaru, Waimate, and Dunroon.

These residential receptors are presented in Table 2 and shown in Figure 3.

<b>Table 2: Location of Receptors close to the Plant</b>			
<b>Receptor Name</b>	<b>Address</b>	<b>Closest Distance to Plant (m)</b>	<b>Direction Relative to Plant</b>
R1	77 Mairos Road, Morven	1,250	N
R2	190 Mairos Road, Morven	1,300	NE
R3	197 Mairos Road, Morven	1,500	NE
R4	362 Archibalds Road, Morven	3,400	NE
R5	540 Archibalds Road, Morven	4,300	NE
R6	425 Carrolls Road, Glenavy	2,350	E
R7	91 Andrews Road, Glenavy	1,800	SE
R8	70 Andrews Road, Glenavy	1,600	SE
R9	319 Andrews Road, Glenavy	3,400	SE
R10	42 Parker Street, Glenavy	2,000	S
R11	Glenavy School	2,300	S
R12	26 Te Maiharoa Road, Glenavy	1,750	SW
R13	192 Glenavy Tawai Road, Glenavy	2,800	SW
R14	4636 Waimate Highway, Morven	1,800	W
R15	212 Waihao Back Road, Waimate	16,000	NW
R16	387 McEneaney Road, Pukeuri	15,500	S
R17	Dunroon School	33,000	W



Figure 3: Sensitive Receptor Location



## 2.5 Airshed

In 2005 regional councils and unitary authorities identified areas throughout New Zealand where ambient concentrations of pollutants (primarily PM<sub>10</sub>) could reach levels higher than the National Environmental Standards for Air Quality (NESAQ). These areas are designated as airsheds. Airsheds serve as a management tool for regional councils to assist with controlling levels of pollutants within the defined airshed area. Regional councils have the responsibility to monitor concentrations of air pollutants within these airsheds and may implement rules and regulations to ensure that air quality is maintained at levels below the NESAQ.

As shown in Figure 4 the closest airsheds to the site are Waimate (18 km northwest) and Oamaru (16 km southwest).

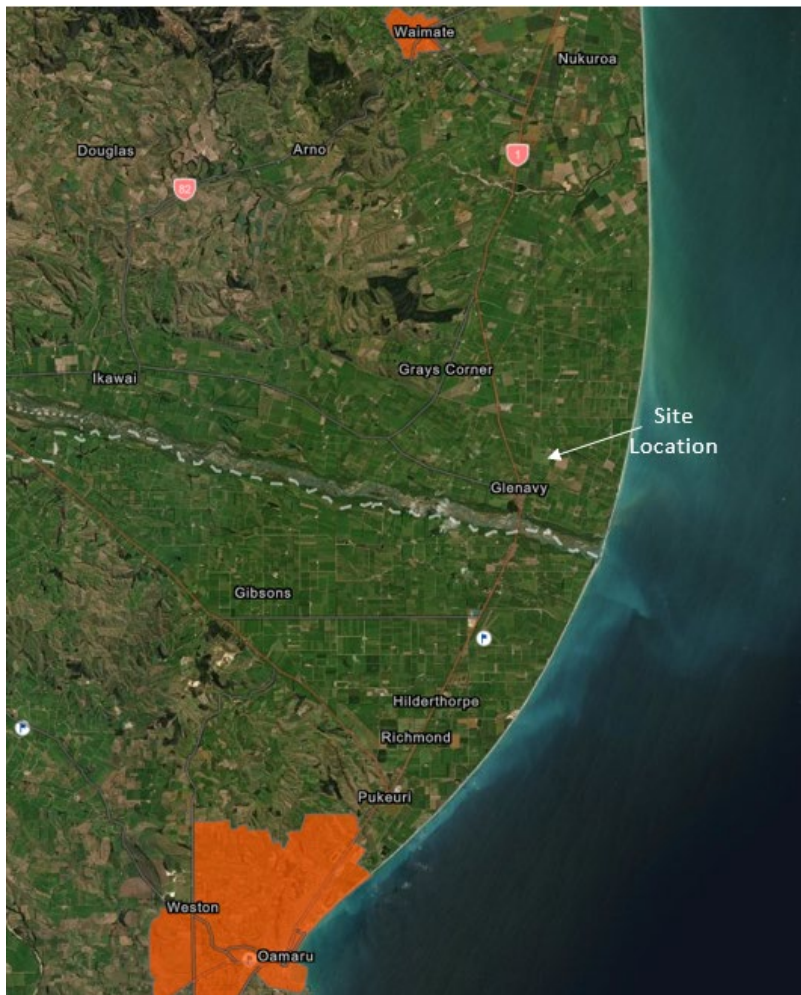


Figure 4: Waimate and Oamaru Airshed Locations

The Waimate airshed is considered polluted under Section 17(4) of the NESAQ which states:

(4) For the purposes of this regulation, -

(a) an airshed becomes a polluted airshed on and from 1 September 2012 or any later day if, for the immediately prior 5-year period, -

- i) The airshed has meaningful PM<sub>10</sub> data for at least a 12-month period, and
- ii) The airsheds average exceedances of PM<sub>10</sub> (as calculated under regulation 16D) was more than 1 per year, and

(b) An airshed stops being a polluted airshed on and from any day if the PM<sub>10</sub> standard was not breached in the airshed in the immediately prior 5-year period.

Figure 5 shows the PM<sub>10</sub> concentrations recorded by ECan in Waimate for the past five years (May 2017 to May 2022), indicating that the NESAQ for PM<sub>10</sub> of 50 µg/m<sup>3</sup> has been exceeded on a number of occasions. Therefore, PDP has concluded that the Waimate Airshed is currently a polluted airshed based on this data.

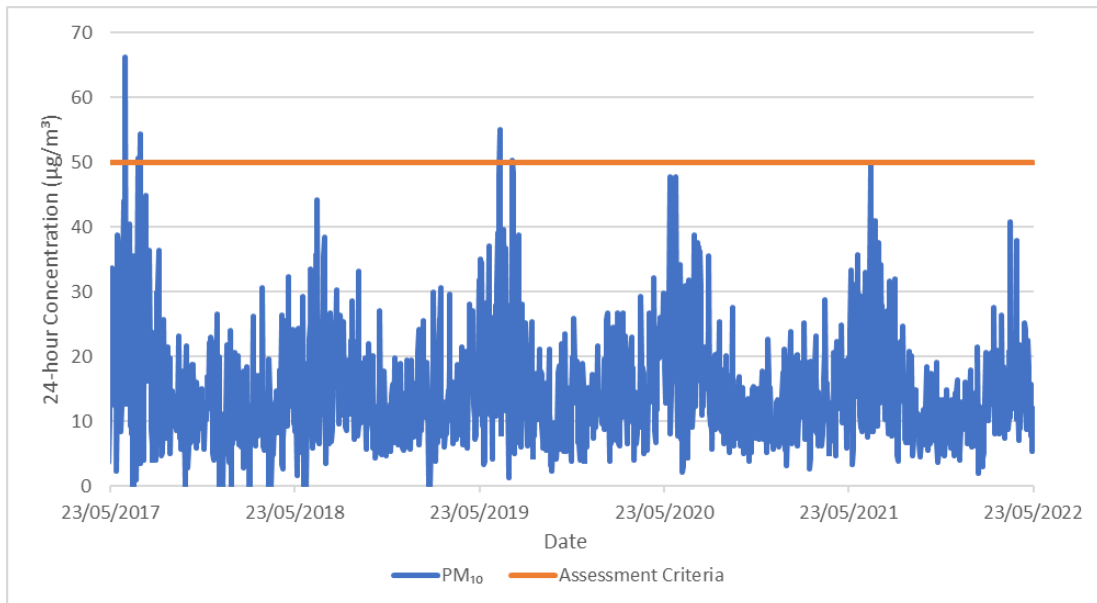


Figure 5: Waimate Airshed Daily PM<sub>10</sub> Concentrations

## 2.6 Background Air Quality

The Proposed Site is located in a rural part of South Canterbury and is a distance from large townships and cities. Consequently, there are no air quality monitoring stations in the immediate vicinity. This absence of air quality monitoring (in particular for rural areas) is due to the general expectation that the air quality will be at an acceptable level.

The nearest air quality monitoring station to the site is located in Waimate 18 km northwest and is operated by the ECan. However, as this monitor is located within a polluted airshed (as mentioned in Section 2.5), it is unlikely to be representative of the background concentrations at the site.

Waka Kotahi<sup>3,4</sup> has developed background concentrations for the entire country, including the area unit in which the Proposed Site is located. This is considered more representative of the background concentrations than data from Waimate. As there is no 24-hour PM<sub>10</sub> concentration, PDP has calculated the background PM<sub>10</sub> concentration based on guidance from the Auckland Council<sup>5</sup>, which based on its monitoring data, has determined that 24-hour PM<sub>2.5</sub> concentrations are 37 percent of 24-hour PM<sub>10</sub> concentrations in rural areas.

Table 3 presents the selected background data used in this assessment, which is based on Waka Kotahi background data (area unit Waihao) and the default values from GPG ID<sup>6</sup> (where no background concentrations could be determined).

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<sup>3</sup> Tonkin + Taylor, *Background Annual Average Nitrogen Dioxide Concentrations*, December 2020

<sup>4</sup> Tonkin + Taylor, *Particulate Matter Background Air Quality Maps – Summary of methodology*, June 2020

<sup>5</sup> Auckland Council, *Use of Background Air Quality Data in Resource Consent Application*, July 2014.

<sup>6</sup> Ministry for the Environment, *Good Practice Guide for Assessing Discharges to Air from Industry*, November 2016.

Table 3: Background Air Quality Data			
Pollutant	Averaging Period	Concentration ( $\mu\text{g}/\text{m}^3$ )	Source
PM <sub>10</sub>	24-hour	10.0	Waihao
	Annual	8.1	Waihao
PM <sub>2.5</sub>	24-hour	3.7	Waihao
	Annual	2.3	Waihao
NO <sub>2</sub>	1-hour	37	Waihao
	24-hour	23	Waihao
	Annual	3	Waihao
Sulphur Dioxide (SO <sub>2</sub> )	1-hour	20	MfE ID
	24-hour	8	MfE ID
Carbon Monoxide (CO)	1-hour	5,000	MfE ID
	8-hour	3,000	MfE ID
Volatile organic compounds (VOC)	All averaging periods	0 <sup>1</sup>	-
Dioxins and Furans	All averaging periods	3.8 fg I-TEQ/m <sup>3</sup>	MfE, 1999 <sup>2</sup>
<b>Notes:</b> <ol style="list-style-type: none"> <li>Assumed to be negligible given the lack of nearby anthropogenic sources</li> <li>Mean rural South Island concentration (Culverden) (MfE, Ambient Concentrations of selected organochlorines in air, 1999)</li> </ol>			

## 3.0 Proposed Activities

### 3.1 Project Overview

The overall process description is provided in the Operational & Technical Overview Report attached to the AEE, therefore this section only contains a summary of the activities that will occur, with an emphasis on the potential for discharges to air from the process, including how the various components of the flue gas treatment systems work.

The Proposed Site will contain the following:

- ✧ In / out truck weighbridges;
- ✧ A common waste receival area;
- ✧ A common 7,000 tonne storage bunker for MSW;
- ✧ Two incineration and steam generation lines;
- ✧ Two flue gas treatment lines;
- ✧ Two 75 m stacks (enclosed in a single housing);
- ✧ One 35 MW Steam Turbine;
- ✧ One 36 MW Electricity Generator;
- ✧ One grate ash handling and export system;
- ✧ One fly ash plasma treatment and export system;
- ✧ One water treatment plant;
- ✧ One process wastewater treatment system; and
- ✧ One domestic wastewater treatment system.

Figure 6 provides a schematic representation of the proposed plant, and Appendix B contains plans of the process building.



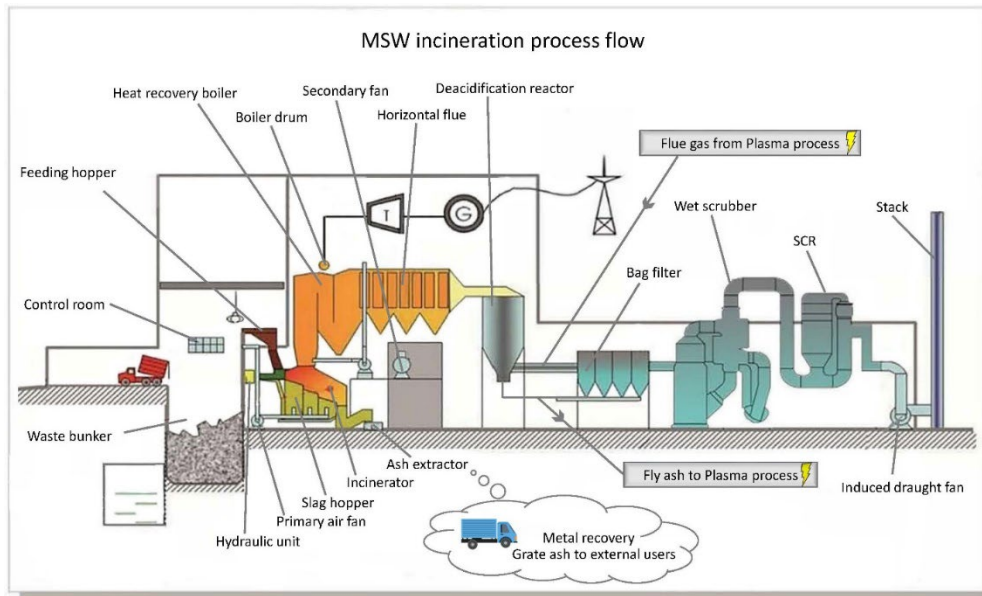


Figure 6: WtE Plant Schematic

### 3.2 Waste Storage

The Proposed Site will incinerate an approximate 50:50 split of MSW and CW. CW will be delivered to the site and stored separately, as described in the following sections.

#### 3.2.1 Municipal Solid Waste

MSW will arrive via trucks and be unloaded directly into the waste storage bunker. Figure 7 shows waste being unloaded into the waste bunker, which has been designed to hold up to seven days of waste. As can be seen in Figure 7, when waste is not being unloaded the bunker is sealed off from the receival hall. This minimises the potential for odours to be detected in the receival area.



**Figure 7: Waste receival hall showing trucks unloading into the waste bunker**

To further minimise the potential for fugitive odours from the waste bunker it will be held under negative pressure.

This negative pressure (nominally -50Pa) is developed by drawing all of the primary combustion air from the incinerator from the bunker. Each combustion unit requires approximately 96,000 m<sup>3</sup>/h of air which means that with both units operating there is 2.8 air changes<sup>7</sup> in the waste bunker, or 1.4 air changes with one unit operating. This level of extraction is sufficient to maintain negative pressure within the waste bunker. As air will be drawn out of the waste receival area into the waste bunker, this area will also be maintained at a slight negative pressure.

In addition, SIRRL is also proposing a secondary odour control system for the waste bunker. This system, which would only be operated in the event that both of the combustion systems were off-line, will consist of a two stage wet scrubber<sup>8</sup>. The scrubber system will extract approximately 13,000 m<sup>3</sup>/h of air from the waste bunker and maintain it under a slight negative pressure. The first stage of the scrubber will contain a 30% Hydrogen Chloride (HCl) solution and the second stage a 30% sodium hydroxide (NaOH) solution. The two chemical solutions will effectively destroy the various odour causing compounds that are

<sup>7</sup> The total volume of the waste bunker is approximately 70,000 m<sup>3</sup>

<sup>8</sup> It is noted that each stage has three treatment vessels which allows for redundancy in the operation.

released from waste stored in the bunker. Based on PDP's experience this unit will achieve a minimum 80% removal of any odorous compounds.

Figure 8 is an image of the odour scrubber at a site in China, though it is noted that at the proposed plant the unit will be located inside the building envelope rather than outside.



**Figure 8: Image of the secondary odour control scrubber**

PDP notes that based on its experience a secondary treatment system such as that proposed is not typically included in European plants, with the waste bunker simply isolated in the event that the incinerators are off-line. Therefore the inclusion of such a system is considered to provide a level of protection which is over and above that typically deemed to be satisfactory.

### 3.2.2 Construction Waste

Baled CW will arrive at the Proposed Plant by one of two methods:

- ∴ In standard shipping containers. Containers to be removed from rail and placed on the truck for unloading into the waste storage bunker. Both full and empty containers may be stored on-site on a suitable hardstand area.
- ∴ In curtain sider type truck or rail car. CW would be supplied baled and unloaded into either:
  - A dump truck for immediate transfer inside the waste storage bunker; or
  - Placed in storage on-site inside a warehouse for later use. The warehouse where the CW will be stored is an enclosed facility.

The CW storage capacity is 48,000 tonnes. This has been assumed based on the size of the bales and how many would fit in the proposed warehouse.

It is not considered that this baled material poses any risk of generating discharges to air and therefore no specific controls are required when it is being stored.

One of the potential components of CW is CCA-treated timber. Any metals released from the CCA-treated timber during combustion will be captured and treated in flue gas treatment system, the same as any other residual metals in the MSW and CW.

### 3.3 Main Furnace Air Emissions

The main air emissions will occur from the combustion of MSW and diesel. Diesel will only be used during certain circumstances, i.e. during the start-up of boilers and maintaining the flue gas temperature above 850°C should the MSW momentarily have a very low calorific value. An overview of the gas flue treatment system is provided in Figure 9.

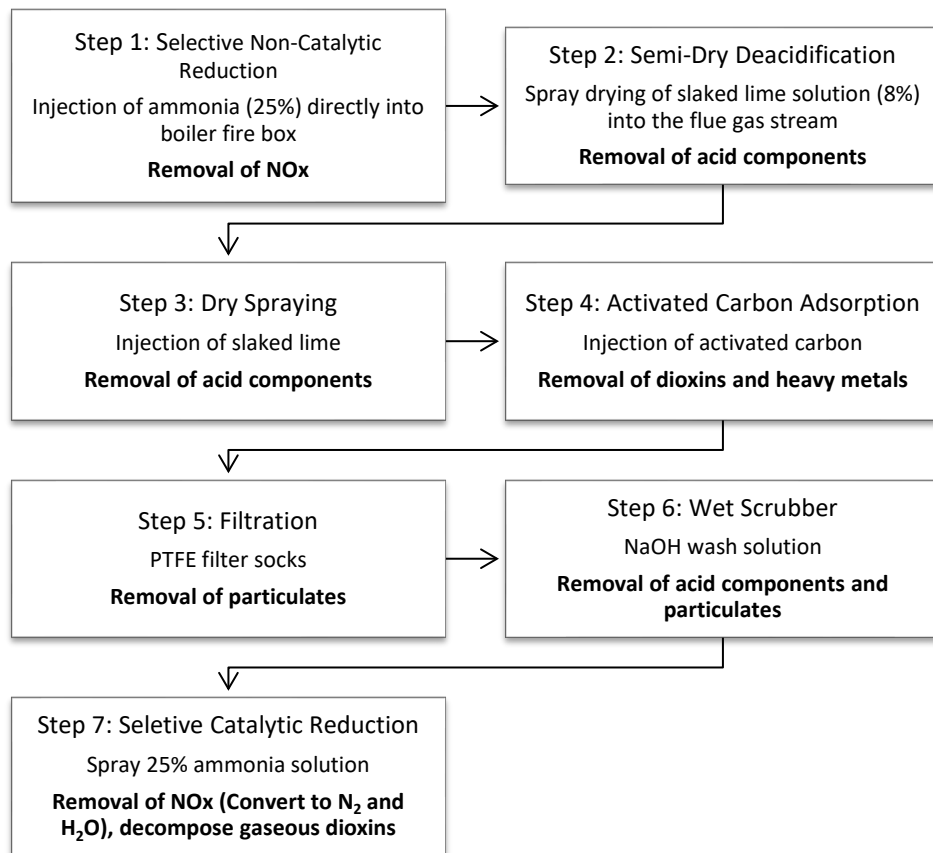


Figure 9: Main Flue Gas Treatment System

### 3.3.1 Furnace Feed

MSW is transferred directly from the waste bunker onto the feed chutes to the furnaces, which are located within the waste bunker using large grapples. There is no potential for any form of discharge to air from this process.

Baled CW will be loaded directed into the waste bunker via a shredder which is located within the waste receival hall. It is not considered that this activity will generate any discharges to air.

### 3.3.2 Furnace

In the furnace, waste is combusted on a moving grate with the non-combustible material (bottom ash or grate ash) falling out of the end of the furnace through a water bath, which functions both as a vacuum seal to minimise air entering the furnace, and to cool the bottom ash prior to further processing.

The cooled bottom ash is stored in a bunker prior to further processing described in Section 3.5. This material is wet and enclosed and does not have any potential to result in any discharges to air.

Any fly ash entrained in the combustion products is drawn through the waste heat boiler where heat is transferred to water and subsequently used to generate steam. The waste heat boiler has been designed such that any fly ash that falls out of suspension is collected and transferred back to be processed with the bottom ash. This collection system is fully enclosed system and there is no potential for any discharges to air from it.

Any fly ash that remains suspended in the combustion air is treated in the flue gas treatment system that is described in Section 3.6.

## 3.4 Steam Generation

The heat from the combustion process is transferred to water to generate steam which is then used to drive a 35 MW steam turbine that is connected to a 36 MW electricity generator, with the electricity that is generated being fed into the local network. There are no discharges to air from this process but for completeness the process is briefly described below.

The walls and roof of the combustion of the furnace are constructed of pipes, which have water passing through them. As the water heats it boils creating steam which is stored in a steam drum.

Saturated steam is drawn off the steam drum and then passes through the superheater where further heat is drawn from the combustion gases.

The superheated steam is then fed into the steam turbine which is connected to an electric generator. The system has been designed to operate in one of two modes 100% electricity generation or 70% electricity and 30% steam for use by external users.

Finally, the now low pressure steam exiting the steam turbine is condensed back into water using cooling towers and recycled back into the boiler feed water system.

### 3.5 Bottom Ash Processing

Approximately 8.7 tonnes/day of bottom ash will be produced by the two furnaces. This will be processed to remove recoverable metals before being removed from site. All processing will be carried out inside the building envelope and there is little potential for discharges to air.

Firstly the bottom ash will pass through a magnetic separator to remove ferrous metals and then eddy current separation will be used to remove any non-ferrous metals (e.g. aluminium and copper). SIRRL is expecting to recover in the order of 5,500 tonnes per year of metals.

The residual material will then be stored prior to being loaded into trucks for export to aggregate customers.

Given that the processing will occur inside the building envelope and the bottom ash is damp, it is unlikely that this will give rise to any off-site dust effects.

### 3.6 Flue Gas Treatment

As identified in Figure 6 each of the furnaces will be connected to a seven stage flue gas treatment system, which is designed to treat approximately 155,900 Nm<sup>3</sup>/h of flue gas.

#### 3.6.1 Selective non catalytic nitrogen oxide reduction (SNCR)

The first stage of the treatment process is SNCR. This involves spraying an 25% aqueous solution of ammonia into the high temperature combustion gases in the boiler firebox prior to it passing through the superheater. The ammonia reacts with the nitrogen oxide to create nitrogen and water. The system is designed to reduce nitrogen oxide levels to below 200 mg/Nm<sup>3</sup>. The SNCR system also has the potential to control the temperatures in the boiler firebox.

As this process forms part of the flue gas treatment system there is no potential for direct discharges to air from this treatment step.

The storage and handling of the anhydrous ammonia is dealt with in the Hazardous substances report (Technical Report 3), however in brief the site will have storage for 50,000 Litres of anhydrous ammonia, which will be delivered at the correct concentration and stored in appropriate tanks. While there is potential for discharges of small quantities of anhydrous ammonia during tank filling this is extremely unlikely to result in any form of off-site effects.

### 3.6.2 Semi-dry deacidification

The second stage in the treatment process is semi dry deacidification. This occurs after the flue gas exits the economiser and involves using a rotary atomiser to spray an 8% lime slurry into the gas stream at the top of the reactor tower. Once the water evaporates the lime reacts with the acidic components in the gas stream (e.g. hydrogen chloride, hydrogen fluoride and sulphur dioxide) to form a range of calcium compounds. The residence time in the reactor is approximately 20 seconds and the flue gas exits at approximately 155°C.

Some of the solids formed in the process are collected in the bottom of the reactor and are removed to the fly ash treatment system. This process is an enclosed system. The remainder of the solids remain in the flue gas and are removed in subsequent treatment steps.

There are no potential discharges to air from this process.

Lime is brought onto site in trucks and pneumatically conveyed directly into the storage silo. The conveying air will be discharged via an integrated pulse jet bag house with the clean air venting inside the building structure. The silo will also be fitted with high level alarms which will prevent it being overfilled.

It is unlikely that there will be any discharges to air associated with this process or with the mixing of the lime and water prior to the slurry being utilised.

### 3.6.3 Dry Deacidification

After the flue gas leaves the reactor tower, dry lime is sprayed into the gas stream. This reacts with any remaining acidic components in the gas stream to neutralise them. The quantity of lime injected is proportional to the flowrate of the flue gas.

There are no discharges to air from this process with material removed from the gas stream in the baghouse discussed in Section 3.7.

The lime is transferred directly from the lime silo as discussed in the previous section.

### 3.6.4 Activated carbon

Following the dry deacidification, activated carbon is injected into the gas stream. The activated carbon absorbs any organic compounds including dioxins and furans (typically referred to collectively as dioxins), polyaromatic hydrocarbons (PAHs), polychlorinated biphenyls (PCBs) and PFAS plus any volatile heavy metals such as mercury that might be in the flue gas.

As with the dry lime injection the quantity of carbon required will be proportion to the gas flow rates but based on experience at other sites it will be in the order of 13 kg/hour per treatment line.



The activated carbon will be delivered to site in one tonne bulk bags and stored inside the building until required. The activated carbon will then be transferred to a storage hopper as required prior to being transferred to the flue gas treatment system.

The unloading of the bags together with the storage silos will be inside the building envelope and is unlikely to generate any discharges to air.

### 3.6.5 Bag Filter

The flue gas then passes through a bag filter which filters out the majority of the fly ash present in the gas stream, including the carbon and lime added by the previous two processes steps.

Each bag filter unit will be divided into 16 compartments which can be individually isolated, to allow for individual cells to be taken off-line for bag replacement if required.

The filtration velocity<sup>9</sup> for each bag filter unit is approximately 0.7 metres per minute. This is considerably less than the maximum air to cloth ratio recommended by the Auckland Council<sup>10</sup> of 3 metres per minute for this type of bag filter unit and therefore represents best practice.

All particulate collected in the baghouse is transferred via enclosed conveyors and screws to the fly ash treatment system discussed in Section 3.7.

The bags used in filter units are made from PTFE which is appropriate for this environment and the temperature range that the bag filter units will operate in.

There is no potential for any discharges to air from the bag filter units.

### 3.6.6 Wet Scrubber

Following the bag filter unit the flue gas passes through the wet scrubber. In the scrubber a 30% solution of NaOH is sprayed into the gas stream to remove any remaining acidic compounds.

Prior to leaving the scrubber the flue gas is dehumidified, and then passes through a heat exchanger that cools the flue gas entering the scrubber to less than 100°C.

This type of treatment represents good practice.

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<sup>9</sup> Calculated by dividing the maximum gas flow rate of approximately 4,000 m<sup>3</sup>/min by the total filter area for each baghouse of 5,800 m<sup>2</sup>.

<sup>10</sup> Auckland Regional Council, Technical Publication 152 – Assessing Discharges of Contaminants to Air (draft), April 2002



### 3.6.7 Selective Catalytic Reduction (SCR) Denitrification

The final state of the flue gas system is SCR. In the SCR system a 25% ammonia solution is injected into the gas stream which then passes over a vanadium titanium catalyst to promote the conversion of NO<sub>x</sub> to N<sub>2</sub>. The catalytic reaction also further oxidises any remaining dioxins and PCBs.

To promote the catalytic reaction the reaction chamber is heated to 240°C. The flue gas is then cooled to 145°C prior to discharge to atmosphere with the recovered heat used to warm the flue gas entering the reactor.

## 3.7 Fly ash treatment

The fly ash collected by the main flue gas treatment train is transferred to the fly ash treatment system which converts it to a solid slag through vitrification. The process which is described in section 12.2 of Report 1, combines the fly ash with a number of additives and then feeds them into the plasma furnace. The plasma furnace which operates at very high temperatures (8,000 – 10,000°C) melts the fly ash into a liquid which is then tapped into quench bath that vitrifies (freezes) the liquid into a slag. This material is then crushed and stored before being taken off-site to customers. A schematic of the process is provided in Figure 10.

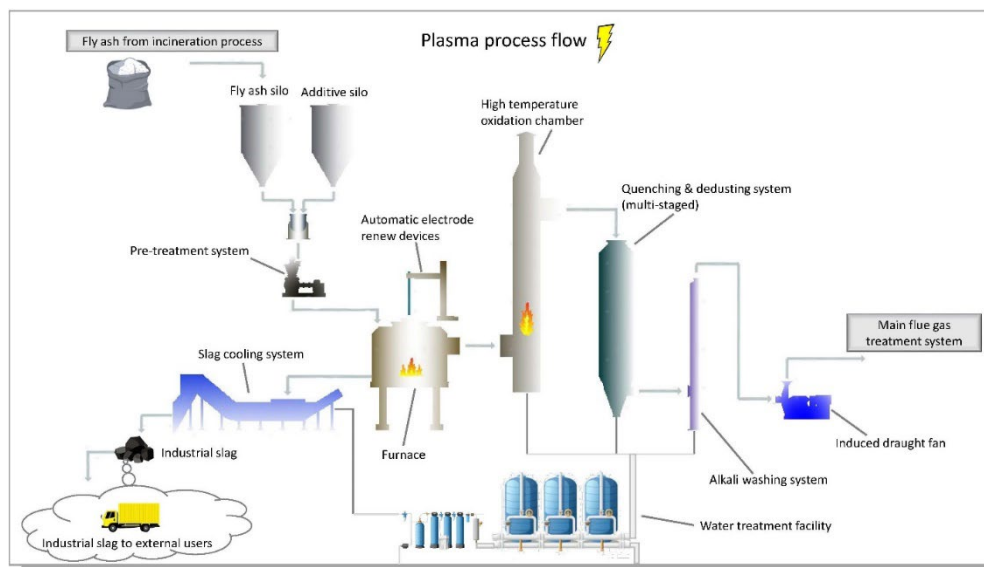
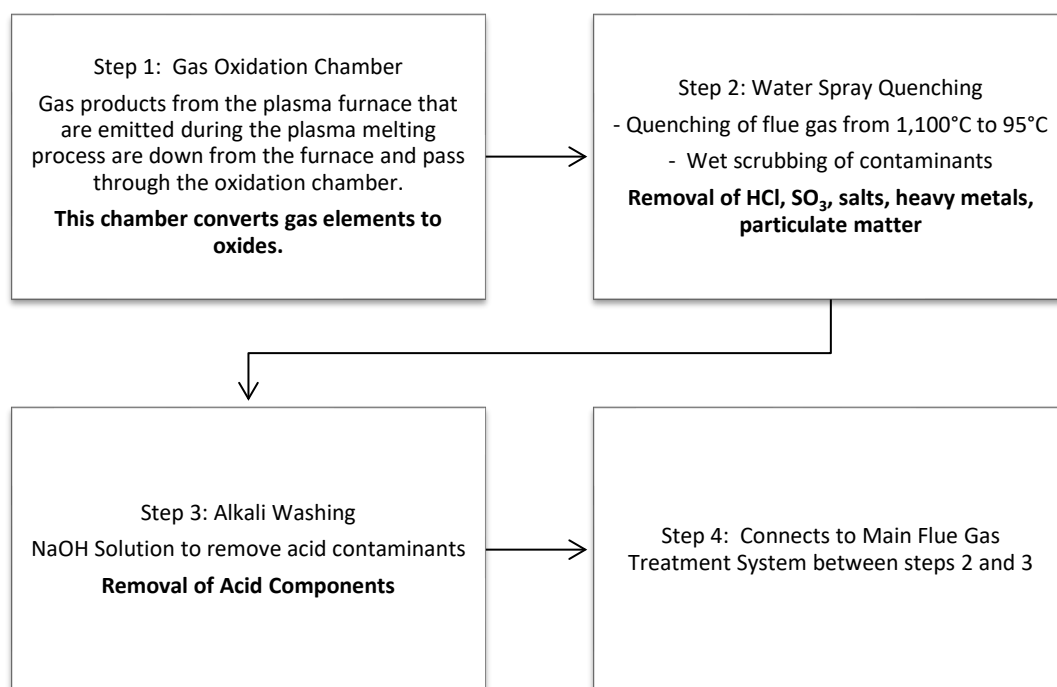


Figure 10: Schematic of fly ash treatment process

### 3.7.1 Plasma furnace off-gas treatment

The plasma furnace off-gases are treated in a dedicated two stage treatment system prior to being combined with the flue gas from the main furnace after the denitrification reactor. This system is designed to treat approximately 1,500 Nm<sup>3</sup>/hour of flue gas. The specific steps are identified in Figure 11, and described in the following sections.



**Figure 11: Plasma Flue Gas Treatment System**

#### 3.7.1.1 Oxidation

The first step of the treatment process involves the oxidation of products of combustion. This involves introducing a small amount of diesel (approximately 14 kg/h) and air into the hot gas stream which results in a combustion process that oxidises any compounds that are present in the gas stream.

There are no direct discharges to air from this process.

#### 3.7.1.2 Water quench

Following the oxidation process, the off-gases enter the quench chamber where temperatures are rapidly reduced to below 100°C. In addition, this process will remove particulate and any water soluble gaseous compounds that may be present in the gas stream.

### 3.7.1.3 Alkali washing

The gas stream then enters a vessel containing a 30% NaOH solution which removes any acidic compounds that may be present in the gas stream such as sulphur dioxide.

### 3.7.1.4 Connection to Flue gas treatment system

Following the alkali washing, the gas stream is then sent to one of the furnace gas treatment systems after the deacidification reactor, and will go through the remaining five stages of treatment prior to discharge to air via the main stack. To provide for flexibility and allow for system maintenance the semi treated gas stream will be able to be sent to either of the main treatment streams.

## 3.8 Best Practice Emission Control

The European Commission has published a document<sup>11</sup> for Waste Incineration which identifies the Best Available Techniques (BAT) for the control of emissions from the activity, including the control of discharges to air. Set out in Table 4 is a comparison of the emission control for Project Kea against the European BAT.

It is important to note that the BAT document states that in each category that BAT is to use one or a combination of the techniques. It is not necessary to use all of the techniques.

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<sup>11</sup> : Frederik Neuwahl, Gianluca Cusano, Jorge Gómez Benavides, Simon Holbrook, Serge Roudier; Best Available Techniques (BAT) Reference Document for Waste Incineration; EUR 29971 EN; doi:10.2760/761437

<b>Table 4: Comparison of Best Available Techniques</b>		
<b>Emissions</b>	<b>BAT</b>	<b>Comment</b>
Dust metals and metalloids	Bag filter Electrostatic precipitator Dry sorbent injection Wet scrubber Fixed or moving bed absorption	Project Kea is utilising a bag house as the primary dust control, with dry absorbent injection and the wet scrubber removing the metals
HCl, HF and SO <sub>2</sub>	Wet scrubber Semi wet scrubber Dry sorbent injection Direct desulphurisation Boiler sorbent injection	Project Kea is employing all these techniques apart from direct desulphurisation which is not applicable to the fixed bed furnace that is being used.
NO <sub>x</sub> , N <sub>2</sub> O, CO and NH <sub>3</sub>	Optimisation of the incineration process Flue gas recirculation SNCR SCR Catalytic filter bags Optimisation of SNCR/SCR design Wet scrubber	Project Kea is using both SNCR and SCR to control NO <sub>x</sub> and N <sub>2</sub> O, together with optimisation of the incineration process.  The wet scrubber will also assist in removing these compounds.
Organic compounds including dioxins and PCBs	Optimisation of the combustion process Control of waste feed On-line and off-line boiler cleaning Rapid flue gas cooling Dry sorbent injection Fixed or moving bed absorption SCR Catalytic filter bags Carbon sorbent in a wet scrubber	Project Kea is using a combination of these techniques to control organic compounds. No control of the waste feed is being implemented as is not considered applicable to MSW, fixed or moving bed absorption, catalytic bags or carbon sorbent in a wet scrubber.
Mercury (Hg)	Low pH wet Scrubber Dry sorbent injection Injection of highly reactive carbon Boiler bromine addition Fixed or moving bed absorption	Project Kea uses dry absorbent injection to control Hg.

Based on this review all of the components of the flue gas treatment system constitute BAT.

### 3.9 Start-Up Diesel Generators

Project Kea is designed to run off the electricity generated on site, however during the initial start-up and following significant maintenance shutdowns, the facility will not produce electricity and therefore relies on an external source. Three 2 MW diesel powered generators will be installed at the site to provide this. Other than the initial commission period, it is predicted that the generators will not be required more than one day per year, however they will need to be operated periodically for testing. When testing is required, they will be operated individually.

These units will produce a range of combustion products which are assessed in Section 6.6.

## 4.0 Assessment Criteria

This section of the report identifies the relevant assessment criteria or standards that potential air discharges associated with the Proposed Site must meet.

### 4.1 Regional Rules

The relevant regional rules related to air emissions from the Proposed Site are found in the Canterbury Air Regional Plan (CARP).

*7.63 The discharge of contaminants into air:*

- 1) that does not comply with one or more of the conditions of Rules 7.47 to 7.62, excluding condition 1 of Rules 7.47, 7.48, 7.49, 7.50 7.51, 7.55, 7.59 and 7.62; or*
- 2) that is from an industrial or trade premise and is not managed by Rules 7.47 -7.62; and is not a prohibited activity, is a discretionary activity.*

The Proposed Plant also falls under the jurisdiction of the Waimate District Plan. Under this plan the site is a Discretionary Activity:

*5.3: Any activity which is not listed as Permitted Activity, a Controlled Activity, or a Restricted Discretionary Activity, and which complies with all Zone Standards in Rule 8 shall be a Discretionary Activity.*

## 4.2 Combustion Emissions Guidelines

The GPG ID<sup>12</sup> recommends an order of priority when reviewing air quality assessment criteria. The documents outlined below set out the minimum requirements that ambient air quality should meet in order to protect human health and the environment. This order of priority is as follows:

- ∴ MfE, Resource Management (National Environmental Standards for Air Quality) Regulations, 2004 (MfE, 2004);
- ∴ MfE Ambient Air Quality Guidelines (2002 update) (NZAAQG) (MfE, 2002);
- ∴ Canterbury Air Regional Plan, 2017 (CARP);
- ∴ World Health Organisation (WHO) air quality guideline (WHO AQG) Global Update 2005 (WHO, 2006);
- ∴ California Office of Environmental Health Hazard Assessment Reference Exposure Limits (OEHHA REL) [www.oehha.ca.gov/air.html](http://www.oehha.ca.gov/air.html);
- ∴ US Environmental Protection Agency's Inhalation Reference Concentrations (US EPA RfC) [www.epa.gov/iris/limits.htm](http://www.epa.gov/iris/limits.htm);
- ∴ Texas effects screening levels (providing that these have been derived from toxicological data in a transparent manner) (Texas ESL) <http://tceq.texas.gov/toxicology/esl>; and
- ∴ Worksafe New Zealand Workplace Exposure Standards WES TWA divided by 50 for low and moderately toxic hazardous air contaminants or divided by 100 for highly toxic bio-accumulative or carcinogenic hazardous air contaminants.

Appendix C sets out in detail the rationale developed by Dr Jackie Wright of EnRisk<sup>13</sup> for selecting the various assessment criteria.

Briefly the assessment criteria for metals is based on the inhalation criteria used in the human health risk assessment. It should be noted that no acute assessment criteria have been identified for beryllium, cobalt, lead, thallium, selenium, tin and dioxin as these are either not acute toxicants or no suitable acute inhalation values are available.

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<sup>12</sup> Ministry for the Environment, *Good Practice Guide for Assessing Discharges to Air From Industry*, November 2016.

<sup>13</sup> Environment Risk Sciences, *Project Kea: Human Health Risk Assessment*, September 2022.

Based on the order of priority recommended by GPG ID<sup>14</sup>, the air quality assessment criteria are presented in Table 5. These standards and guidelines have been specifically developed to protect the health of the most sensitive individuals; therefore, if off-site concentrations are less than them, there is no potential for adverse human health effects.

It should be noted that the MfE has proposed a review of the NESAQ including adopting a PM<sub>2.5</sub> standard, although it is unclear when these will be progressed. For the purpose of this assessment the values in MfE's discussion document<sup>15</sup> have been adopted.

The WHO has recently released an updated AQG, which is more stringent than those in its previous advice. The AQG are presented as interim targets and a final AQG. The contaminants covered by these updated AQG are PM<sub>2.5</sub>, PM<sub>10</sub>, ozone (O<sub>3</sub>), NO<sub>2</sub>, SO<sub>2</sub> and CO. The 24-hour PM<sub>2.5</sub>, PM<sub>10</sub>, NO<sub>2</sub>, SO<sub>2</sub> and CO guidelines are the 99<sup>th</sup> percentile value (i.e. 3-4 exceedance days per year). At this stage these AQG have not been adopted in New Zealand, therefore, PDP has used the current NESAQ and NZAAQG in preference. Section 4.5.2 and Section 4.5.4 of the HHRA<sup>16</sup> compares the updated guidelines to those used in this assessment.

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<sup>14</sup> Ministry for the Environment, *Good Practice Guide for Assessing Discharges to Air From Industry*, November 2016.

<sup>15</sup> Ministry for the Environment, *Proposed amendments to the National Environmental Standards for Air Quality: particulate matter and mercury emissions – consultation document*. February 2020

<sup>16</sup> EnRiskS, *Project Kea: Human Health Risk Assessment*, November 2022.

**Table 5: Relevant Assessment Criteria for the Proposed Plant**

Pollutant	Assessment Concentration ( $\mu\text{g}/\text{m}^3$ )	Averaging Period	Source	Permissible exceedance in a 12-month period
Ammonia ( $\text{NH}_3$ )	590	1-hour	TEXAS ESL	No allowance
	320	Annual	TEXAS ESL	No allowance
Antimony (Sb)	1.0	1-hour	ATSDR <sup>17</sup>	No allowance
	0.3	Annual	ATSDR <sup>10</sup>	No allowance
Arsenic (As)	9.9	1-hour	TEXAS ESL	No allowance
	0.0055	Annual	NZAAQG	No allowance
Benzene (VOC)	580	1-hour	TEXAS ESL	No allowance
	3.6	Annual	NZAAQG	No allowance
Beryllium (Be)	0.02	Annual	WHO	No allowance
Cadmium (Cd)	18	1-hour	TEXAS ESL	No allowance
	0.005	Annual	WHO	No allowance
Carbon Monoxide (CO)	30,000	1-hour	NESAQ / NZAAQG	One 8-hour period
	10,000	8-hour	NESAQ	No allowance

<sup>17</sup> Guideline available from the Agency for Toxic Substances and Disease Registry (ATSDR), as an acute air guideline (relevant to exposures from 1 hour to 14 days) <https://www.atsdr.cdc.gov/mrls/index.html>



**Table 5: Relevant Assessment Criteria for the Proposed Plant**

Pollutant	Assessment Concentration ( $\mu\text{g}/\text{m}^3$ )	Averaging Period	Source	Permissible exceedance in a 12-month period
Chromium VI	1.3	1-hour	TEXAS ESL	No allowance
	0.0011	Annual	NZAAQG	No allowance
Cobalt (Co)	0.1	Annual	WHO	No allowance
Copper (Cu)	100	1-hour	OEHHA REL	No allowance
	490	Annual	USEPA <sup>18</sup>	No allowance
Dioxins	$3.5 \times 10^{-6}$	Annual	USEPA	No allowance
Hydrogen Chloride	660	1-hour	TEXAS ESL	No allowance
	26	Annual	TEXAS ESL	No allowance
Hydrogen Fluoride	60	1-hour	TEXAS ESL	No allowance
	29	Annual	TEXAS ESL	No allowance
Lead	0.2	3-month rolling average	NZAAQG	No allowance
Manganese (Mn)	9.1	1-hour	TEXAS ESL	No allowance
	0.15	Annual	WHO	No allowance

<sup>18</sup> No specific inhalation-based concentration

**Table 5: Relevant Assessment Criteria for the Proposed Plant**

Pollutant	Assessment Concentration ( $\mu\text{g}/\text{m}^3$ )	Averaging Period	Source	Permissible exceedance in a 12-month period
Hg	0.6	1-hour	OEHHA REL	No allowance
	0.13 (organic)	Annual	NZAAQG	No allowance
Nickel (Ni)	1.1	1-hour	TEXAS ESL	No allowance
	0.02	Annual	UK EA 2009	No allowance
NO <sub>2</sub>	200	1-hour	NESAQ	Nine 1-hour periods
	100	24-hour	NZAAQG	No allowance
	40	Annual	WHO AQG	No allowance
PM <sub>10</sub>	50	24-hour	NESAQ / RAAQG	One 24-hour period
	20	Annual	NZAAQG / RAAQG	No allowance
PM <sub>2.5</sub>	25	24-hour	Proposed NESAQ/ CARP	Three 24-hour periods
	10	Annual	Proposed NESAQ / CARP	No allowance
Selenium (Se)	20	Annual	OEHHA REL	No allowance
SO <sub>2</sub>	350	1-hour	NESAQ	Nine 1-hour periods
	570	1-hour	NESAQ	No allowance
	120	24-hour	NZAAQG	No allowance

**Table 5: Relevant Assessment Criteria for the Proposed Plant**

Pollutant	Assessment Concentration ( $\mu\text{g}/\text{m}^3$ )	Averaging Period	Source	Permissible exceedance in a 12-month period
Thallium	0.7	Annual	USEPA	No allowance
Tin	700	Annual	USEPA	No allowance
Toluene	15,000	1-hour	TEXAS ESL	No allowance
	5,000	Annual	US EPA RfC	No allowance
1,3,5- and 1,3,4-trimethylbenzene	15,000	1-hour	TEXAS ESL	No allowance
	60	Annual	US EPA RfC	No allowance
Vanadium (V)	30	1-hour	OEHHA REL	No allowance
	0.1	Annual	ATSDR <sup>19</sup>	No allowance
M & p xylene	7,400	1-hour	TEXAS ESL	No allowance
	200	Annual	ATSDR <sup>12</sup>	No allowance

<sup>19</sup> Guideline available from the Agency for Toxic Substances and Disease Registry (ATSDR), as an acute air guideline (relevant to exposures from 1 hour to 14 days) <https://www.atsdr.cdc.gov/mrls/index.html>

### 4.3 Odour Emission Guidelines

Based on rural zoning of the area surrounding the proposed Plant, the MfE Odour recommended guideline of 5-10 OU/m<sup>3</sup> for a Low Sensitivity Receiving Environment is considered appropriate. However due to the presence of a number of sensitive receptors (discussed in Section 2.4), in the area PDP has used the guideline value of 2 OU/m<sup>3</sup> for a High Sensitivity Environment. Table 6 presents the MfE odour guidelines.

Table 6: MfE Odour Guidelines		
Sensitivity of the Receiving Environment	Concentration	Percentile
Residential Areas	2 OU/m <sup>3</sup>	0.1 and 0.5%
Industrial / Rural Areas	5 – 10 OU/m <sup>3</sup>	0.5%

### 4.4 Dust Deposition Guidelines

The MfE Dust<sup>20</sup> sets out recommended trigger levels for deposited dust. This is provided in Table 7.

Table 7: MfE Dust Deposition Guidelines		
Trigger	Averaging Period	Trigger Levels
Monthly	30 Days	4 g/m <sup>2</sup> /30 days

## 5.0 Assessment Methodology

### 5.1 Modelling Technique

The atmospheric dispersion modelling assessment was conducted using CALPUFF (Version 7), which has been extensively used in New Zealand and Australia and is a recommended model in the GPG ADM<sup>21</sup> particularly for sites surrounded by complex terrain and/or in complex settings. CALPUFF was developed in the United States and has been used extensively throughout the world. It was previously the United States Environmental Protection Agency's recommended model.

<sup>20</sup> Ministry for the Environment, *Good Practice Guide for Assessing and Managing Dust*, November 2016.

<sup>21</sup> Ministry for the Environment, *Good Practice Guide for Atmospheric Dispersion Modelling*, June 2004.

CALPUFF was used in preference to AERMOD, the current US EPA preferred model, due to CALPUFF's ability to utilise complex three dimensional meteorology and more realistically calculate off-site effects at windspeeds below 0.5 metres per second.

## 5.2 Model Set up

The CALPUFF model was set up in accordance with the guidance contained in the GPG ADM<sup>22</sup>.

A two-year dataset from 1 January 2019 to 31 December 2020 was developed in line with good practice. This time period includes both El Niño (partially 2019 and the first quarter of 2020), and La Niña (2020) climatic conditions<sup>23</sup>. Given this, it is considered that the choice of 2019 to 2020 provides a suitably wide range of meteorological conditions appropriate for the dispersion modelling assessment. As well as creating a three dimensional wind speed and direction data field for each hour of the year, CALMET also calculates parameters such as atmospheric stability and mixing heights, which allow the model to determine when inversion effects are occurring.

The CALMET meteorological data required by CALPUFF that was not available from local meteorological stations was created using the prognostic meteorological model TAPM (version 4,0.4), CSIRO, Australia<sup>24</sup> and local meteorological data.

Appendix D provides detailed information on the model set up including information on:

- ✧ TAPM Prognostic model set up;
- ✧ Meteorological stations inputted into the model;
- ✧ CALMET stability classes and mixing heights; and
- ✧ Land use and Terrain heights incorporated into the CALPUFF model.

The CALPUFF model was configured to predict contaminant ground level concentrations (GLC) at a number of discrete receptor locations (Section 2.4) as well as over two nested grids. The nested grids were centred at UTM 508,750 m E and 5,028,673 m S and went out to 2,000 and 3,500 m with a receptor spacing of 50 and 100 m, respectively.

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<sup>22</sup> Ministry for the Environment, *Good Practice Guide for Atmospheric Dispersion Modelling*, June 2004.

<sup>23</sup> NIWA, *Monitoring ENSO: Southern Oscillation Index*, August 2021

<sup>24</sup> Peter Hurley, *TAPM V4 User Manual. CSIR Marine and Atmospheric Research Internal Report No. 5*. October 2008.

The presence of buildings and other structures close to stacks can result in building downwash effects on plumes, where the wind in the wake of the building can pull a plume towards the ground. To account for this effect, the buildings and structures within 200 m of the stacks were included in the CALPUFF model. The effect of building downwash was accounted for using the Building Profile Input Program (BPIP) Plume Rise Model Enhancements (PRIME) building downwash algorithm. Figure 12 and Figure 13 indicate the location of the buildings used in the CALPUFF model and the discharge points.

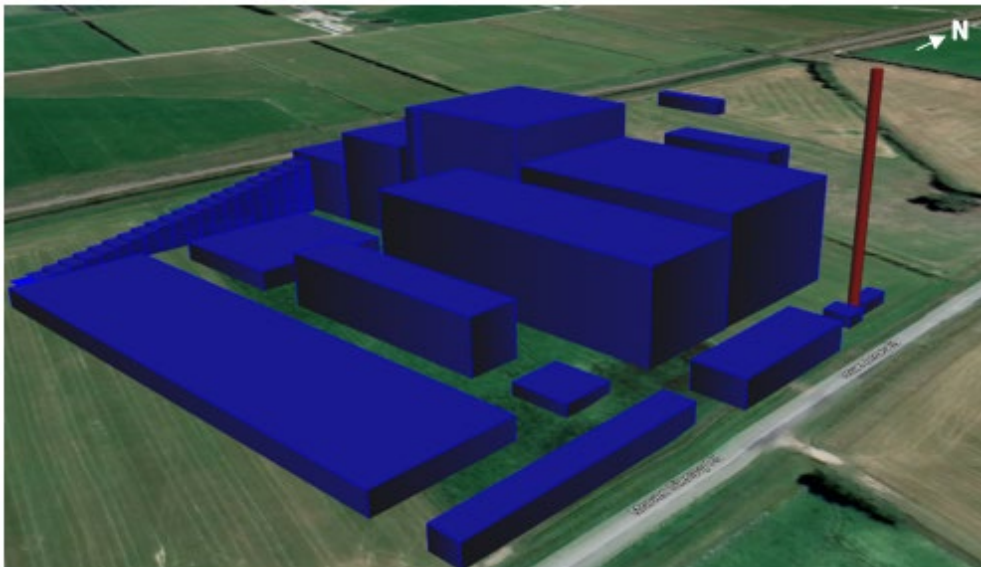


Figure 12: Simplified CALPUFF Building Configuration View A

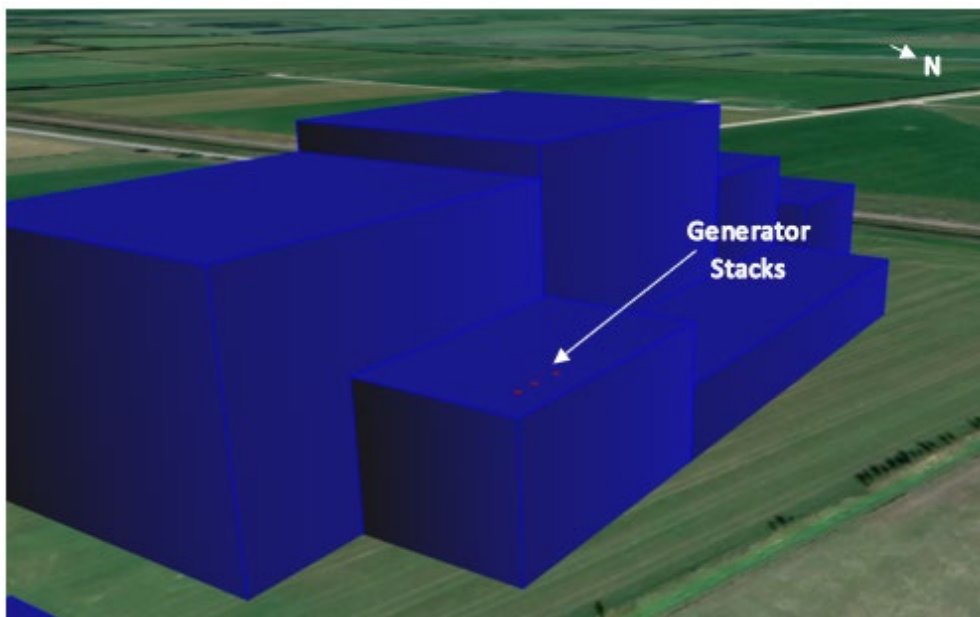


Figure 13: Simplified CALPUFF Building Configuration View B

### 5.3 Stack Discharge Parameters

The Proposed Site will have two incinerators, each with its own flue gas treatment system and exhaust stack. As the stacks will be contained within a single common housing, one combined stack has been modelled in accordance with the GPG ADM<sup>25</sup>. Table 8 presents the stack parameters inputted into the air dispersion model and includes the stack parameters for the three onsite generators.

Table 8: Plant Discharge Modelling Parameters					
Parameter	Unit	Incinerator Stacks	Modelled Stack	Odour Scrubber	Generator
Exit gas temperature	(°K)	418.15	418.15	293.15	827.5
Internal stack diameter	(m)	2.5	3.54	2.48	0.44
Gas exit velocity	(m/s)	13.5	13.5	0.7	47.7
Overall Stack Emission	(Nm <sup>3</sup> /hr)	155,865	311,730	12,000	9,420
Stack Height	(m)	75	75	38	25

### 5.4 Stack Emission Rates

Project Kea is being designed to meet the emission limits that are set out in EU Directive 210-75-EU Annex VI Part 3 (EU Standard), with these values being guaranteed by the Plant designer. Therefore, conservatively PDP has calculated the emissions on the basis that each of the compounds is present at the maximum concentration allowed by the standard with the values presented in Table 9. An analysis of actual emissions against emission limits for the designers operating sites in China is provided in Appendix E, with a summary provided in Section 5.5. The emission rates from the site have been calculated using the total emission rate from the two stacks. However, as Table 9 only contains an emission concentrations for total metals, the individual emission rates for the metals assessed have been calculated separately in Section 5.4.1. In addition, odour emission rates and dust deposition has been calculated in Section 5.4.2 and Section 5.3.3, respectively.

<sup>25</sup> Ministry for the Environment, *Good Practice Guide for Atmospheric Dispersion Modelling*, June 2004.

Table 9: Guarantee Emission Values for the Project				
Pollutant	Unit	Daily Average Value	Emission Concentration Used	Emission rate (g/s)
Particle	mg/Nm <sup>3</sup>	<2-5	5	0.76 <sup>26</sup>
HCl	mg/Nm <sup>3</sup>	<2-6	6	0.91
HF	mg/Nm <sup>3</sup>	≤1	1	0.15
SO <sub>2</sub>	mg/Nm <sup>3</sup>	5-30	30	4.57
NO <sub>x</sub>	mg/Nm <sup>3</sup>	50-120	120	18.26
CO	mg/Nm <sup>3</sup>	10-50	50	7.61
TVOC	mg/Nm <sup>3</sup>	<3-10	10	1.52
NH <sub>3</sub>	mg/Nm <sup>3</sup>	2-10	10	1.52
Hg	µg/Nm <sup>3</sup>	<5-20	20	0.003
Total Metals	mg/Nm <sup>3</sup>	0.01-0.3	0.3	-
Dioxin	ngTEQ/Nm <sup>3</sup>	0.06	0.06	9.13 x 10 <sup>-9</sup>

#### 5.4.1 Metals

As the metal emission value in Table 9 are only provided for total metal concentrations, a typical breakdown of the composition of the flue gas from the CNTY<sup>27</sup> plant has been analysed (Table 10) and used to determine the individual metal emission rates.

In order to model the emission rate for different metals, PDP has made a number of assumptions. These are as follows:

- ∴ The metals, with the exception of Hg will primarily partition onto the particulate and therefore the particulate concentrations can be used to provide an estimate of the metal concentrations.
- ∴ All Chromium is Chromium VI.

Based on the above PDP has conservatively modelled all metals in Table 10 as 1% of the PM concentration (0.076 g/s) in Table 9.

<sup>26</sup> PDP has assumed that this value applies to both PM<sub>10</sub> and PM<sub>2.5</sub>

<sup>27</sup> CNTY is one of the partners in SIRRL and is providing the technology for plant.



Measured emission rates for two metals (arsenic and thallium) were not available and the emission rates for them has been derived as follows:

- ∴ Thallium has been assumed to be present at a similar percentage as cadmium (0.04%)<sup>28</sup>; and
- ∴ Arsenic has been assumed to be present at twice the percentage of chromium (0.2%)<sup>29</sup>.

Table 10: XRF analysis of Flue gas particulate			
Metal	Percentage	Metal	Percentage
Calcium	35.9%	Zinc	0.5%
Oxygen	23.4%	Titanium	0.4%
Chlorine	17.7%	Lead	0.2%
Silicon	4.3%	Phosphorous	0.2%
Potassium	3.6%	Bromide	0.2%
Sulphur	2.5%	Chromium	0.1%
Iron	2.5%	Manganese	0.1%
Sodium	2.4%	Strontium	0.1%
Water	2.2%	Copper	0.1%
Carbon	1.5%	Barium	0.1%
Aluminium	1.1%	Cadmium	0.04%
Magnesium	1.1%	Nickel	0.01%

#### 5.4.2 Odour

The site has two main odour sources onsite. The incinerator stacks and the standby odour scrubber. There is no odour emission data available for these sources, so PDP has assumed an odour emission concentration of 500 OU/m<sup>3</sup> for both of these sources. This value has been selected based on PDP's experience with emissions post odour control devices from other emission sources. These sources have been analysed separately as the scrubber will only be operating if the incinerators are not operating.

<sup>28</sup> <https://majorprojects.planningportal.nsw.gov.au/prweb/PRRestService/mp/01/getContent?AttachRef=SSD-10395%2120200922T045415.001%20GMT>. Table 6-12

<sup>29</sup> Rogers J et al, Department and management of metals produced during combustion of CCA-treated timbers, Journal of Hazardous Materials, A139 (2007) 500-505

PDP has conservatively assumed that the scrubber will remove at least 80% of the odorous compounds. This means that a concentration of 500 OU/m<sup>3</sup> coming out of the scrubber stack is the equivalent of 2,500 OU/m<sup>3</sup> going in. Having undertaken visits to a number of waste incinerators in Europe, PDP considers that the odours within the waste bunker are comparable to that which might be experienced in a large transfer station. PDP has worked on a number of these and undertaken ambient odour monitoring adjacent to some of them. This monitoring indicates that odour concentrations within the waste transfer station were between 500 and 1,000 OU/m<sup>3</sup>. Given that there could be some differences between the waste bunker and a transfer station PDP has applied a factor to the increase the input odour concentration to 2,500 OU/m<sup>3</sup>.

PDP has also undertaken some additional assessments, in the event that inlet odour concentrations are greater than 2,500 OU/m<sup>3</sup>:

- ∴ 2,000 OU/m<sup>3</sup> coming out of the scrubber (10,000 OU/m<sup>3</sup> going in) as this is a common manufacture guarantee value; and
- ∴ 5,000 OU/m<sup>3</sup> (or 25,000 OU/m<sup>3</sup> going in).

#### 5.4.3 Dust Deposition

Dust deposition for particles has been estimated using the default dust deposition properties in CALPUFF. This is:

- ∴ Geometric Mass Mean Diameter (microns) = 0.48
- ∴ Geometric Standard Deviation (microns) = 2

The same particle emissions rate of 0.76 g/s has been used.

#### 5.4.4 Generators

The exact generator model/manufacture that will be used onsite is unknown at this stage, however it is known that each of the generators will be 2 MW. Based on this PDP has estimated the likely emissions using Caterpillar C3516B-HD generators on-site. This results in an emission rate of:

- ∴ NO<sub>x</sub> – 5.64 g/s
- ∴ CO – 0.671 g/s
- ∴ PM – 0.0507 g/s

### 5.5 Comparison of Emissions from similar plants

The proposed plant is designed to meet the European emission standard as mentioned previously, and PDP has conservatively modelled emissions at the emission limit to ensure the worst-case emissions from the plant have been assessed. However, based on PDP's actual emissions from operating plants are well less than the emissions limits.

### 5.5.1 CNTY Operating Plants

To demonstrate this PDP has compared actual monitoring data from two of CNTY operating plants in China and are operating to the Chinese emission standard. This comparison is presented in Table 11. As shown the two plants are operating well below their respective standards<sup>30</sup> (shown in brackets) and below the European standard that Project Kea is designed to meet.

While this comparison does not include all of the potential contaminants it does provide an indication of how the plants overseas operate in relation to their respective standards, and provides assurance that Project Kea will be able to meet the emission limits proposed.

Additional test data has been provided in Appendix E which includes some of the metals and dioxins. This data indicates that the plants are operating well below the Chinese standard.

Table 11: Emission Values comparison				
Pollutant	Unit	Kea Emission limits	Average Shenzhen Discharge concentrations	Average Minquan discharge concentrations
Particle	mg/Nm <sup>3</sup>	5	1 (10)	2 (20)
NOx	mg/Nm <sup>3</sup>	120	45 (80)	101 (250)
SO <sub>2</sub>	mg/Nm <sup>3</sup>	30	2 (50)	29 (80)
HCl	mg/Nm <sup>3</sup>	6	2 (10)	5 (10)
CO	mg/Nm <sup>3</sup>	50	1 (50)	2 (80)

### 5.5.2 Tirme Plant - Mallorca

PDP has also reviewed monitoring data for the Tirme plant in Mallorca which is provided as percentage of the European standard and therefore direct comparison with the concentrations in Table 11 is unable to be undertaken. Looking at the Tirme daily results for November 2022 it can be seen that the plant has been operating at levels less than 50% of its standard for NOx and SO<sub>2</sub> and less than 25% for CO, HCl, particulates and TOC<sup>31</sup>.

<sup>30</sup> The reason that the standards are different is that the Minquan was designed to meet the older Chinese standard and the Shenzhen plant the updated standard.

<sup>31</sup> [https://www.tirme.com/pg\\_02a.php?id=3&id1=25&em=3424](https://www.tirme.com/pg_02a.php?id=3&id1=25&em=3424)

## 5.6 Magnitude of Change

PDP has assessed the scale of potential effects at the receptor locations associated with emissions to air from the site using the ‘magnitude of change’ criteria and the ‘significance’ criteria in Table 12 and Table 13.

These criteria have been developed based on the example assessment criteria for air quality provided in the UK’s Institute of Air Quality Management (IAQM) guidance document<sup>32</sup>. This approach is considered to be in line with the MfE’s compliance strategy for PM<sub>10</sub><sup>33</sup>.

Table 12: Methodology for Predicting Scale (Magnitude) of Impacts on Air Quality		
Magnitude	Description	Examples
Large	Impact resulting in a considerable change in baseline environmental conditions	A significant change which involves a variation in predicted concentration of more than 5% of the criteria for PM <sub>10</sub> and PM <sub>2.5</sub> , and more than 10% of the criteria for other compounds
Medium	Impact resulting in a discernible change in baseline environmental conditions	A noticeable change which involves a variation in predicted concentrations of 2.5% to 5% of the criteria for PM <sub>10</sub> and PM <sub>2.5</sub> , and 5% to 10% of the criteria for all other compounds
Imperceptible	No discernible change	An imperceptible change which involves a variation in predicted concentrations of <2.5% of the criteria
<p>Notes:</p> <ol style="list-style-type: none"> <li>Magnitude of change may show an increase (adverse impact of air quality) or a decrease (beneficial impact of air quality).</li> <li>‘Baseline environmental conditions’ are defined as ‘background air quality’ or the ambient air quality concentrations of a pollutant without the project</li> </ol>		

<sup>32</sup> Position of the Description of Air Quality Impacts and the Assessment of their Significance, Institute of Air Quality Management (IAQM), November 2009

<sup>33</sup> Clean healthy air for all New Zealanders; The National Air Quality Compliance Strategy to meet the PM<sub>10</sub> standard, MfE, August 2011

**Table 13: Predicting the Significance of Impacts on Air Quality**

Absolute Concentration in Relation to the Assessment Criteria	Magnitude of Impact on Air Quality		
	Imperceptible	Medium	Large
Increase with Project/Scheme			
Above Assessment Criteria <i>with</i> Project/Scheme (Exceedance of assessment criteria)	Slight, Adverse: <i>Minor</i>	Moderate, Adverse: <i>More than Minor</i>	Substantial, Adverse: <i>More than Minor</i>
Just Below Assessment Criteria <i>with</i> Project/Scheme (100% to 90% of assessment criteria)	Slight, Adverse: <i>Less than Minor</i>	Moderate, Adverse: <i>Minor</i>	Moderate, Adverse: <i>More than Minor</i>
Below Assessment Criteria <i>with</i> Project/Scheme (90% to 75% of assessment criteria)	Negligible	Slight, Adverse: <i>Less than Minor</i>	Slight, Adverse: <i>Minor</i>
Well Below Assessment Criteria <i>with</i> Project/Scheme (Less than 75% of assessment criteria)	Negligible	Negligible	Slight, Adverse: <i>Less than Minor</i>

## 6.0 Assessment of Effects

### 6.1 Combustion Emissions

#### 6.1.1 Nitrogen Dioxide

PDP has analysed the effects of NO<sub>2</sub> using the method set out in the GPG ID<sup>34</sup>. As recommend in the GPG ID, for one-hour averages, the 99.9<sup>th</sup> percentile value should be used. The NO<sub>2</sub> screening model assumes that all nitrogen oxides from the source are nitrogen dioxide. The cumulative concentration is represented in the following equation.

$$NO_2 = NO_x(\text{model}) + NO_2(\text{Background})$$

The predicted maximum off-site 1-hour and 24-hour NO<sub>2</sub> concentrations including background are presented in Table 14 and are compared to the relevant assessment criteria. A graphical presentation of the 99.9<sup>th</sup> percentile 1-hour and maximum 24-hour NO<sub>2</sub> ground level concentration (GLGs) excluding background are presented in Figure 14 and Figure 15, respectively.

Predicted NO<sub>2</sub> concentrations, including background are below the assessment criteria (provided in Table 5) at all of the sensitive receptor locations identified, with the highest 1-hour average of **69.0 µg/m<sup>3</sup>** and the highest 24-hour concentration of **42.6 µg/m<sup>3</sup>** outside the boundary (with background). These values comply with the relevant 1-hour and 24-hour guidelines of 200 µg/m<sup>3</sup> and 100 µg/m<sup>3</sup>, respectively.

The maximum off-site annual concentration (including background) is 3.7 µg/m<sup>3</sup> which is well below the guideline of 40 µg/m<sup>3</sup>.

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<sup>34</sup> MFE. 2016, *Good Practice Guide for Assessing Discharges to Air from Industry*.  
Wellington: MfE

<b>Table 14: Predicted NO<sub>2</sub> Concentrations</b>				
<b>Receptor</b>	<b>Predicted GLC (µg/m<sup>3</sup>)</b>			
	<b>99.9%ile 1-hour mean</b>		<b>Maximum 24-hour mean</b>	
	<b>Site Contribution</b>	<b>Site Contribution + Background</b>	<b>Site Contribution</b>	<b>Site Contribution + Background</b>
Maximum Off-site	32.0	69.0	24.6	47.6
R1	13.2	50.2	3.9	26.9
R2	24.0	61.0	11.7	34.7
R3	19.3	56.3	13.8	36.8
R4	11.9	48.9	7.0	30.0
R5	9.7	46.7	3.0	26.0
R6	18.9	55.9	5.2	28.2
R7	18.0	55.0	5.7	28.7
R8	16.9	53.9	4.6	27.6
R9	13.1	50.1	5.0	28.0
R10	18.8	55.8	10.7	33.7
R11	17.8	54.8	12.4	35.4
R12	16.3	53.3	5.5	28.5
R13	11.8	48.8	3.9	26.9
R14	10.6	47.6	3.7	26.7
R15 – Waimate	3.0	40.0	2.5	25.5
R16 – Oamaru	4.1	41.1	2.5	25.5
R17 - Duntroon	0.6	37.6	0.2	23.2
<b>Standard</b>	<b>200</b>		<b>100</b>	



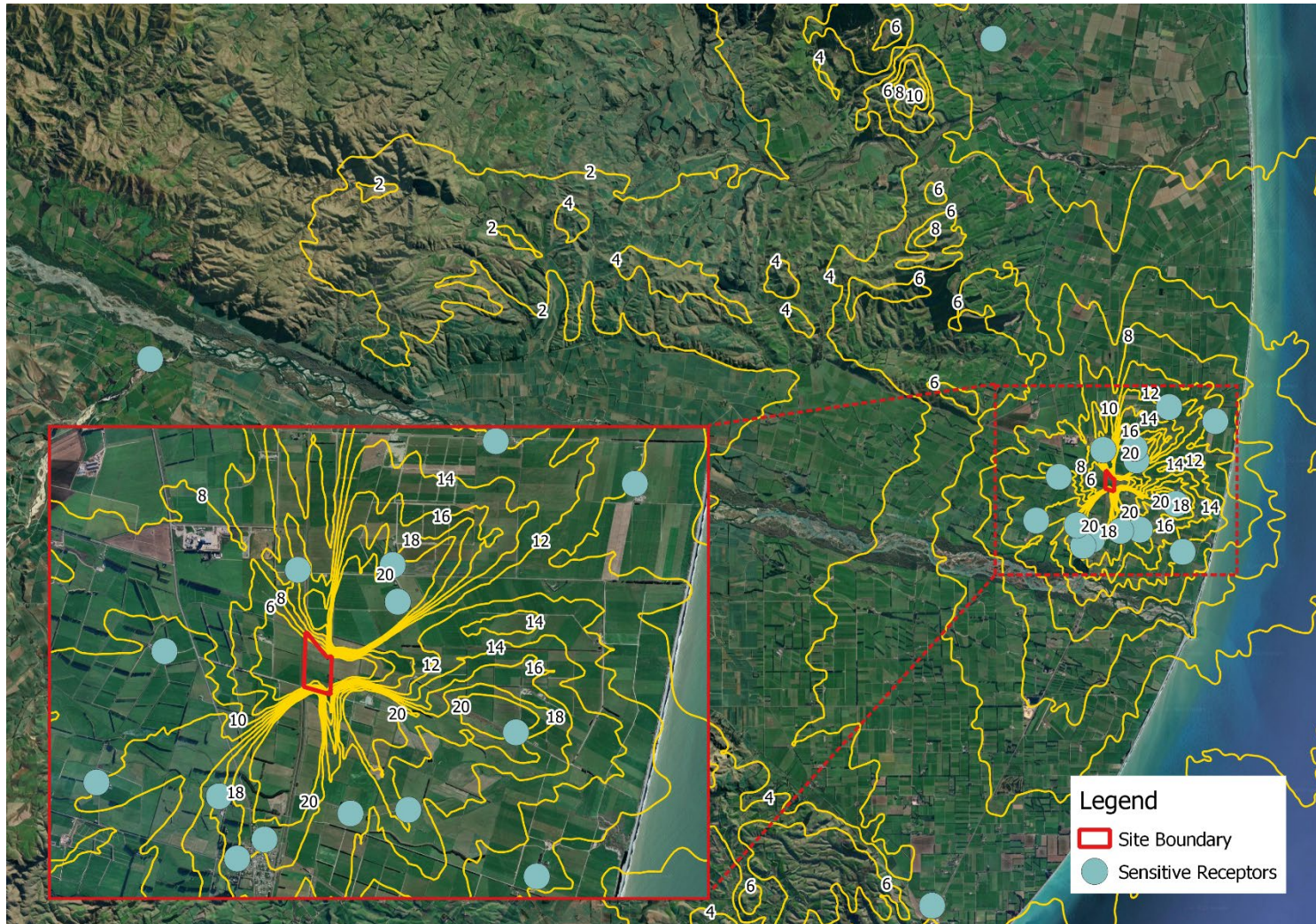


Figure 14: Contour plot of the 99.9%ile 1-hour mean (without background) NO<sub>2</sub> Concentrations



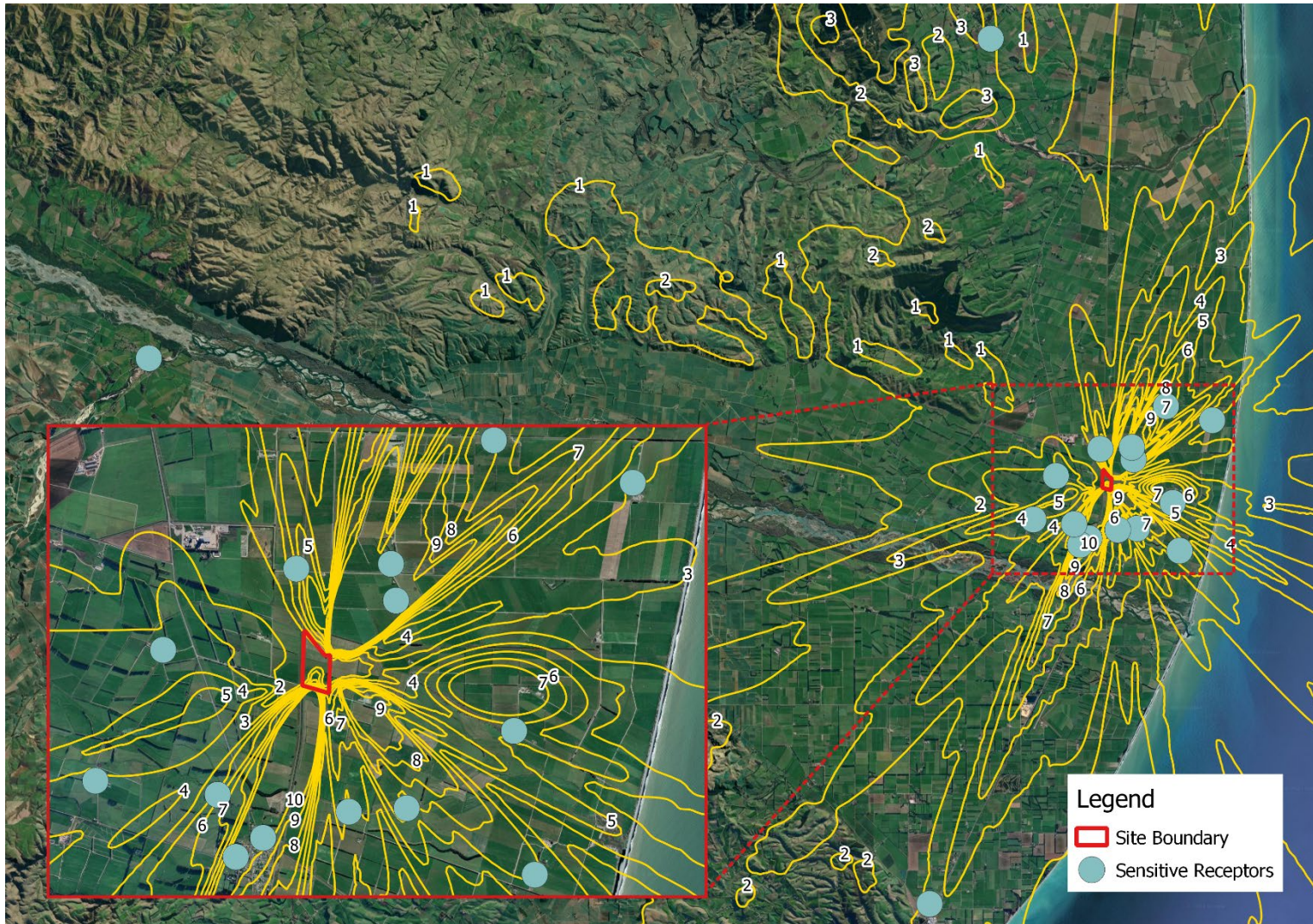


Figure 15: Contour plot of the maximum 24-hour mean (without background) NO<sub>2</sub> Concentrations

### 6.1.2 Sulphur Dioxide

The predicted maximum 1-hour and 24-hour average SO<sub>2</sub> concentrations are presented in Table 15 and are compared to the relevant assessment criteria. Given the low predicted concentrations of SO<sub>2</sub> compared to the assessment criteria (provided in Table 5), no graphical representation is provided for this pollutant.

Predicted SO<sub>2</sub> concentrations, including background concentrations are well below assessment criteria for all the sensitive receptor locations identified with the highest predicted 1-hour average concentration of **42.7 µg/m<sup>3</sup>** and the highest 24-hour average concentration of **14.1 µg/m<sup>3</sup>** outside the site boundary. This complies with the relevant 1-hour and 24-hour guidelines of 350 µg/m<sup>3</sup> and 120 µg/m<sup>3</sup>, respectively. The overall conclusion is that there will be negligible adverse effects associated with SO<sub>2</sub> emissions from the Proposed Site operations.

Table 15: Predicted SO <sub>2</sub> Concentrations				
Receptor	Predicted GLC (µg/m <sup>3</sup> )			
	Maximum 1-hour mean		Maximum 24-hour mean	
	Site Contribution	Site Contribution + Background	Site Contribution	Site Contribution + Background
Maximum Off-site	22.7	42.7	6.1	14.1
R1	7.5	27.5	1.0	9.0
R2	9.9	29.9	2.9	10.9
R3	7.2	27.2	3.4	11.4
R4	5.2	25.2	1.7	9.7
R5	5.8	25.8	0.7	8.7
R6	14.3	34.3	1.3	9.3
R7	8.4	28.4	1.4	9.4
R8	6.9	26.9	1.1	9.1
R9	6.3	26.3	1.2	9.2
R10	11.7	31.7	2.7	10.7
R11	9.4	29.4	3.1	11.1
R12	7.0	27.0	1.3	9.3

Table 15: Predicted SO <sub>2</sub> Concentrations				
Receptor	Predicted GLC (µg/m <sup>3</sup> )			
	Maximum 1-hour mean		Maximum 24-hour mean	
	Site Contribution	Site Contribution + Background	Site Contribution	Site Contribution + Background
R13	8.7	28.7	1.0	9.0
R14	8.9	28.9	0.9	8.9
R15 – Waimate	5.3	25.3	0.6	8.6
R16 – Oamaru	2.0	22.0	0.6	8.6
R17 - Duntroon	0.3	20.3	0.05	8.1
<b>Standard</b>	<b>350</b>		<b>120</b>	

### 6.1.3 Particulate Matter

For this assessment, an emission rate of 0.76 g/s for particulates has been guaranteed by the Proposed Plant designer. PDP has assumed that both PM<sub>10</sub> and PM<sub>2.5</sub> have the same emission rate (0.76 g/s) and therefore the same predicted off-site concentrations apply to both contaminants. Based on this PDP has provided the 24-hour concentrations in Table 16 and the annual concentrations in Table 17 with the relevant background concentration. No graphical representations have been provided, given the low predicted concentrations.

Predicted 24-hour and annual average PM<sub>10</sub> concentrations, including background concentrations are below the assessment criteria (provided in Table 5) at all the sensitive receptor locations identified, with the highest predicted values (including background) of **11.0 µg/m<sup>3</sup>** and **8.1 µg/m<sup>3</sup>**, respectively outside the site boundary. These values comply with the relevant 24-hour and annual guidelines of 50 µg/m<sup>3</sup> and 20 µg/m<sup>3</sup>, respectively.

Predicted 24-hour and annual average PM<sub>2.5</sub> concentrations, including background concentrations are below the assessment criteria at all the sensitive receptor locations identified, with the highest predicted values (including background) of **4.7 µg/m<sup>3</sup>** and **2.3 µg/m<sup>3</sup>**, respectively outside the site boundary. These values comply with the relevant 24-hour and annual guidelines of 25 µg/m<sup>3</sup> and 10 µg/m<sup>3</sup>, respectively.

The overall conclusion is that there will be negligible adverse effects associated with particulate matter emissions from the Proposed Site operations.

<b>Table 16: Predicted 24-hour PM Concentrations</b>			
<b>Receptor</b>	<b>Predicted GLC (<math>\mu\text{g}/\text{m}^3</math>)</b>		
	<b>Site Contribution</b>	<b>Site Contribution + PM<sub>10</sub> Background</b>	<b>Site Contribution + PM<sub>2.5</sub> Background</b>
Maximum Off-site	1.0	11.0	4.7
R1	0.2	10.2	3.9
R2	0.5	10.5	4.2
R3	0.6	10.6	4.3
R4	0.3	10.3	4.0
R5	0.1	10.1	3.8
R6	0.2	10.2	3.9
R7	0.2	10.2	3.9
R8	0.2	10.2	3.9
R9	0.2	10.2	3.9
R10	0.4	10.4	4.1
R11	0.5	10.5	4.2
R12	0.3	10.3	4.0
R13	0.2	10.2	3.9
R14	0.2	10.2	3.9
R15 – Waimate	0.1	10.1	3.8
R16 – Oamaru	0.1	10.1	3.8
R17 - Duntroon	0.007	10.0	3.7
<b>Standard</b>	-	<b>50</b>	<b>25</b>



<b>Table 17: Predicted Annual PM Concentrations</b>			
<b>Receptor</b>	<b>Predicted GLC (<math>\mu\text{g}/\text{m}^3</math>)</b>		
	<b>Site Contribution</b>	<b>Site Contribution + PM<sub>10</sub> Background</b>	<b>Site Contribution + PM<sub>2.5</sub> Background</b>
Maximum Off-site	0.03	8.1	2.3
R1	0.003	8.1	2.3
R2	0.02	8.1	2.3
R3	0.002	8.1	2.3
R4	0.01	8.1	2.3
R5	0.008	8.1	2.3
R6	0.01	8.1	2.3
R7	0.009	8.1	2.3
R8	0.007	8.1	2.3
R9	0.009	8.1	2.3
R10	0.02	8.1	2.3
R11	0.02	8.1	2.3
R12	0.01	8.1	2.3
R13	0.005	8.1	2.3
R14	0.003	8.1	2.3
R15 – Waimate	0.002	8.1	2.3
R16 – Oamaru	0.005	8.1	2.3
R17 - Duntroon	0.0003	8.1	2.3
<b>Standard</b>	-	<b>20</b>	<b>10</b>

#### 6.1.4 Carbon Monoxide

The predicted maximum 1-hour and maximum 8-hour average CO concentrations are presented in Table 18 and are compared to the relevant assessment criteria (provided in Table 5). Given the low predicted concentrations of CO compared to the assessment criteria, no graphical representation is provided for this assessment.

Predicted CO concentrations, including background concentrations are well below assessment criteria for all the sensitive receptor locations identified with the highest predicted 1-hour average concentration of **5,038 µg/m<sup>3</sup>** and the highest 8-hour average concentration of **3,013 µg/m<sup>3</sup>** outside the site boundary. This complies with the relevant 1-hour and 8-hour guidelines of 30,000 µg/m<sup>3</sup> and 10,000 µg/m<sup>3</sup>, respectively.

The overall conclusion is that there will be negligible adverse effects associated with CO emissions from the Proposed Site operations.

Table 18: Predicted CO Concentrations				
Receptor	Predicted GLC ( $\mu\text{g}/\text{m}^3$ )			
	Maximum 1-hour mean		Maximum 8-hour mean	
	Site Contribution	Site Contribution + Background	Site Contribution	Site Contribution + Background
Maximum Off-site	38.1	5,038	13.2	3,013
R1	12.3	5,012	3.9	3,004
R2	16.5	5,017	7.8	3,008
R3	12.1	5,012	7.0	3,007
R4	8.7	5,009	4.2	3,004
R5	9.7	5,010	2.4	3,002
R6	24.1	5,024	6.2	3,006
R7	14.0	5,014	4.4	3,004
R8	11.5	5,012	4.0	3,004
R9	10.6	5,011	3.5	3,004
R10	19.5	5,020	6.9	3,007
R11	15.7	5,016	8.1	3,008
R12	11.6	5,012	4.1	3,004
R13	14.7	5,015	4.8	3,005
R14	14.8	5,015	3.6	3,004
R15 – Waimate	8.9	5,009	2.7	3,003
R16 – Oamaru	3.4	5,003	1.6	3,002
R17 - Duntroon	0.5	5,001	0.2	3,000
<b>Standard</b>	<b>30,000</b>		<b>10,000</b>	

### 6.1.5 Metals

The predicted maximum 1-hour, 3-monthly and annual metal concentrations are presented in Table 19 and are compared to the relevant assessment criteria (provided in Table 5). Given the number of metals that could be emitted from the stack, only the maximum off-site concentration has been provided. No graphical presentation has been provided due to the low assessment criteria.

The overall conclusion is that there will be negligible adverse effects associated with heavy metal emissions from the Proposed Site operations. A breakdown of concentrations at the receptors has been provided in Appendix F.

Table 19: Summary of Maximum off-site concentrations for Metals			
Contaminant	Averaging Period	Maximum Off-site	Assessment Criteria
		(µg/m <sup>3</sup> )	
Antimony (Sb)	1-hour	0.04	1.0
	Annual	2.9 x 10 <sup>-4</sup>	0.3
Arsenic	1-hour	0.01	9.9
	Annual	5.7 x 10 <sup>-5</sup>	0.0055
Beryllium	Annual	2.9 x 10 <sup>-4</sup>	0.02
Cadmium	1-hour	0.04	18
	Annual	2.9 x 10 <sup>-4</sup>	0.005
Chromium VI	1-hour	0.04	1.3
	Annual	2.9 x 10 <sup>-4</sup>	0.0011
Cobalt	Annual	2.9 x 10 <sup>-4</sup>	0.1
Copper	1-hour	0.04	100
	Annual	2.9 x 10 <sup>-4</sup>	490
Lead	3-month	3.7 x 10 <sup>-4</sup>	0.2
Manganese	1-hour	0.04	9.1
	Annual	2.9 x 10 <sup>-4</sup>	0.15
Nickel	1-hour	0.04	1.1
	Annual	2.9 x 10 <sup>-4</sup>	0.02
Selenium	Annual	2.9 x 10 <sup>-4</sup>	20
Thallium	Annual	1.2 x 10 <sup>-5</sup>	0.7
Tin	Annual	2.9 x 10 <sup>-4</sup>	700
Vanadium	1-hour	0.04	30
	Annual	2.9 x 10 <sup>-4</sup>	0.1



### 6.1.6 Other Contaminants

The predicted maximum 1-hour and annual concentrations for the remaining contaminants are presented in Table 20 and are compared to the relevant assessment criteria (provided in Table 5). Given the low predicted off-site concentrations, only the maximum off-site concentration has been provided. No graphical presentation has been provided due to the low assessment criteria. A breakdown of the concentrations at the receptors has been provided in Appendix F.

Table 20: Summary of Maximum off-site concentrations for Contaminants				
Contaminant	Averaging Period	Maximum Off-site	Cumulative Concentration	Assessment Criteria
		(µg/m <sup>3</sup> )		
Benzene	1-hour	7.6	7.6	580
	Annual	0.06	0.046	3.6
Xylene	1-hour	7.6	7.6	7,400
	Annual	0.06	0.06	200
Toluene	1-hour	7.6	7.6	15,000
	Annual	0.06	0.06	5,000
1,3,5- and 1,3,4-trimethylbenzene	1-hour	7.6	7.6	15,000
	Annual	0.06	0.06	60
Mercury	1-hour	0.01	0.01	0.6
	Annual	1.1 x 10 <sup>-4</sup>	1.1 x 10 <sup>-4</sup>	0.13
Ammonia	1-hour	7.6	7.6	590
	Annual	0.06	0.06	320
Dioxin	Annual	3.4 x 10 <sup>-10</sup>	4.1 x 10 <sup>-9</sup>	3.5 x 10 <sup>-6</sup>
Hydrogen Chloride	1-hour	4.5	4.5	660
	Annual	0.04	0.04	26
Hydrogen Fluoride	1-hour	0.8	0.8	60
	Annual	0.006	0.006	29

## 6.2 Odour Emissions

The predicted 1-hour off-site odour concentrations from the stack and scrubber have been assessed separately as the scrubber will only operate when both of the incinerators are off-line.

## 6.3 Stack Odour Emissions

Table 21 presents the 99.5%ile and 99.9%ile 1 hour average odour concentrations that occur when both of the incinerators are operating. Based on PDP’s experience the modelled exit concentration of 500 OU/m<sup>3</sup> is appropriate given the highly treated nature of the flue gas.

As the modelling shows off-site odour concentrations below the standard, the site emission concentrations would need to be up to 10 times higher (5,000 OU/m<sup>3</sup>) for adverse odour to be detected off-site from the stack.

Table 21: Predicted Stack Odour Concentrations		
Receptor	Stack Concentrations 1-hour Predicted GLC (OU)	
	99.9%ile Concentration	99.5%ile Concentration
Maximum Off-site	0.2	0.2
R1	0.1	Less than 0.1
R2	0.2	0.1
R3	0.1	0.1
R4	0.1	0.1
R5	0.1	Less than 0.1
R6	0.1	0.1
R7	0.1	0.1
R8	0.1	0.1
R9	0.1	0.1
R10	0.1	0.1
R11	0.1	0.1
R12	0.1	Less than 0.1
R13	0.1	Less than 0.1
R14	0.1	Less than 0.1
R15 – Waimate	Less than 0.1	Less than 0.1
R16 – Oamaru	Less than 0.1	Less than 0.1
R17 - Duntroon	Less than 0.1	Less than 0.1
<b>Standard</b>	<b>2</b>	

### 6.4 Odour Scrubber

As mentioned in Section 5.2.2, there is not data available on what the odour concentration will be exiting the scrubber. Therefore, PDP has run three scenarios with different odour concentrations, and provided the results in Table 22.

While these results, particularly for the third scenario indicate that stronger odours might be detected close to the site boundary, PDP considers that it is extremely unlikely that odour would be detected at any nearby receptor, particularly when the actual frequency of scrubber operation is taken into effect.

Table 22: Predicted Odour Concentrations			
Receptor	Maximum 1-hour Odour Scrubber Concentration		
	500 OU	2,000 OU	5,000 OU
Maximum Off-site	0.4	1.5	3.6
R1	Less than 0.1	0.3	0.7
R2	Less than 0.1	0.3	0.7
R3	Less than 0.1	0.3	0.7
R4	Less than 0.1	0.2	0.4
R5	Less than 0.1	0.1	0.3
R6	Less than 0.1	0.2	0.5
R7	Less than 0.1	0.2	0.6
R8	Less than 0.1	0.3	0.7
R9	Less than 0.1	0.2	0.4
R10	Less than 0.1	0.4	0.9
R11	Less than 0.1	0.2	0.5
R12	Less than 0.1	0.2	0.5
R13	Less than 0.1	0.2	0.4
R14	Less than 0.1	0.2	0.6
R15 – Waimate	Less than 0.1	Less than 0.1	Less than 0.1
R16 – Oamaru	Less than 0.1	Less than 0.1	Less than 0.1
R17 - Duntroon	Less than 0.1	Less than 0.1	Less than 0.1

### 6.5 Dust Deposition

The predicted maximum 30 day deposition dust concentration off-site has been estimated to be 0.09 g/m<sup>2</sup>/30 days. This is below the MfE guidance of 4 g/m<sup>2</sup>/30 days. A breakdown for the receptor concentrations is provided in Appendix G alongside the annual dust deposition concentrations.

### 6.6 Potential Generator Emissions

As mentioned in Section 3.9 the site will have three 2MW generators on site which are only used during start-up when neither of the incinerations are operational. Therefore the emissions have been considered separately. It is noted that any potential emissions will be for short periods of time and therefore only the 1-hour and 24-hour off-site concentrations have been provided. The predicted off-site concentrations from the generators have been provided in Table 23.

NO<sub>2</sub> concentrations are presumed to be 20% of NO<sub>x</sub> and PM<sub>10</sub> and PM<sub>2.5</sub> emissions are assumed to be 100% of PM emission rates.

Table 23: Summary of Maximum off-site concentrations from the Generators				
Contaminant	Averaging Period	Maximum Off-site	Maximum off-site at a receptor (R2)	Assessment Criteria
NO <sub>2</sub>	1-hour	68.4	27.6	200
	24-hour	15.0	4.0	100
CO	1-hour	203.4	82.1	30,000
	8-hour	85.1	33.7	10,000
PM <sub>10</sub>	24-hour	3.4	0.9	50
PM <sub>2.5</sub>	24-hour	3.4	0.9	20

### 6.7 Cumulative Assessment

Oceania Dairy Limited (Oceania Dairy) is located 1.7 km northwest of the Proposed Site and has the potential to cause cumulative emissions due to both sites producing combustion and odour emissions.

PDP has obtained the discharge to air resource consent for Oceania Dairy and has used the information in the consent to undertake some conservative screening level calculations<sup>35</sup>. The SCREEN3 input has been provided in Table 24.

<sup>35</sup> Using the US EPA screening model SCREEN3

The screening model can only predict 1-hour concentrations, therefore only NO<sub>2</sub> and SO<sub>2</sub> off-site concentrations have been analysed.

**Table 24: Oceania Dairy SCREEN3 Inputs**

Parameter	Unit	Boiler
Source Type	-	Point
Stack Height	m	60
Stack Diameter	m	2
Exit stack velocity	m/s	16
Exit stack temperature	K	413.15
SO <sub>2</sub> Emission rate	g/s	36.1
NO <sub>x</sub> Emission rate	g/s	13.6 <sup>1</sup>

*Notes:*  
 1. Calculated using US EPA AP-42

SCREEN3 predicts that the maximum 1-hour concentration will occur less than 900 m from the source and then decrease. The only receptor that has been identified that can be downwind of both the Proposed Site and Oceania Dairy during the same wind conditions is R7 (located 1.9 and 3.6 km southeast, respectively). Table 25 provides the concentrations predicted at this location and the assessment criteria.

**Table 25: 1-hour GLC at Receptor 7**

Contaminant	Proposed Site	Oceania Dairy	Cumulative Concentration (includes background)	Assessment Criteria
			(µg/m <sup>3</sup> )	
NO <sub>2</sub>	18.0	4.9	59.9	200
SO <sub>2</sub>	8.4	64.4	92.8	350

Based on the cumulative concentrations present at R7 and the conservatism involved with predicting the 1-hour concentration from Oceania dairy. It is predicted that the off-site effects will be less than minor.

Given that these concentrations are well less than the assessment criteria it is extremely unlikely that the other contaminates will result in any effects.

## 6.8 Locality Assessment

As the proposed site is located in proximity to several rural towns, the potential effects on these areas have been summarised below.

### 6.8.1 Glenavy

Glenavy is located to the south of the proposed site, receptors 10 and 11 illustrate the potential effects in Glenavy and have been chosen based on their proximity to the proposed site. The predicted concentration at these locations are well below the relevant guideline values and unlikely to result in adverse health effects.

In terms of odour emissions based on the predicted modelling results it is highly unlikely that offensive and/or objectionable odour will be experienced in Glenavy.

Consequently PDP consider that it is extremely unlikely that emissions from Project Kea will result in any form of adverse effects at Glenavy.

### 6.8.2 Other localities

Waimate, Duntroon and Oamaru: Based on the distance from the proposed site and the predicted modelling results it is highly unlikely that residents of these towns will experience any adverse health effects from the proposed plant or any odour effects.

## 7.0 Proposed Air Quality Consent Conditions

PDP has prepared the following consent conditions that could be included in a resource consent for discharges to air:

### Limits

- 1) Discharge of contaminants into air shall be only from:
  - a. Two 75 m Stacks;
  - b. Ancillary odour treatment system; and
  - c. 36 MW Electricity Generator.

At the energy to waste plant located on the corner of Morven Glenavy Road and Carrolls Road.

- 2) Activities at the site shall not discharge odour, particulate matter or water droplets that result in offensive or objectionable adverse effects beyond the boundary of the property on which the consent is exercised.
- 3) No more than 365,000 tonnes of solid waste shall be processed each year.

**Stacks**

- 4) The individual stacks shall have an emission output not exceeding 155,865 Nm<sup>3</sup>/hr.
- 5) a. Combustion gases from the incinerator shall be discharge to air via the emission control equipment, from two stacks terminating not less than 75 metres above local ground level.  
 b. The discharge from the stack shall be directed vertically onto the air and shall not be impeded by any obstruction above the stack which decreases the vertical efflux velocity from that which would occur in the absence of such an obstruction.
- 6) The opacity of emissions from the stack shall not be darker than Ringelmann Shade 1 as described in New Zealand Standard 5101:1973 except:
  - a. In the case of incinerator re-start for a period not exceeding 15 minutes in the first hour of operation, and
  - b. For a period not exceeding a total of four minutes in each succeeding hour of operation.
- 7) The incinerator stack efflux velocity at a maximum continuous rating of the incinerator shall not be less than 13.5 meters per second.

**Monitoring Requirements – Incinerator**

- 8) Monitoring is to be undertaken as stated in Table 26.

<b>Table 26: Monitoring of Environmental Discharges</b>		
<b>Monitoring Type</b>	<b>Monitoring Items</b>	<b>Monitoring Frequency</b>
Flue Gas	SO <sub>2</sub> , NO <sub>x</sub> , HCl, CO, HF, O <sub>2</sub> , and CO <sub>2</sub>	Real time online monitoring
Waste Analysis	Waste bulk density, moisture content and calorific value	Once per month
Slag	Rate of loss by ignition	Once per month
Dioxin	Dioxin in flue gas	12 hourly sampling tested monthly for first 2 years Twice yearly for year 3 onwards
Odour Pollutants	The odour in the ambient air	Once per quarter
Heavy Metals	Heavy metal in flue gas	Once per quarter

- 9) a. The result of the emission tests and other information and a description of the testing methods shall be provided to the Canterbury Regional Council within 20 working days following receipt of the testing report by the consent holder.  
b. A summary of the results and other information shall also be included in the Annual Environmental Report required by Condition (12)
- 10) a. The tonnage of MSW and CW incinerated each month and the average and maximum hourly consumption rate shall be estimated monthly, based on either the average or maximum electricity production rates and using MSW and CW delivery tonnages as appropriate.  
b. The calculated hourly MSW and CW combustion on a monthly basis shall be summarised in the Annual Environmental Report required by condition (12)

#### Reporting

- 11) A record of all complaints made to the consent holder regarding odour or particulate matter shall be maintained and shall include:
  - a. The location where the odour or particulate matter was detected by the complainant;
  - b. The date and time when the odour or particulate matter was detected;
  - c. Details of the complainant;
  - d. A description of the wind speed and direction and rainfall, if any, when the odour or particulate matter was detected by the complainant;
  - e. The most likely cause of the odour or particulate matter detected;
  - f. Any corrective action undertaken by the consent holder to avoid, remedy or mitigate the odour or matter detected by the complainant if the issues complained about were considered to have been caused by the consent holder's activities.
  - g. The record of complaints shall be provided to the Canterbury Regional Council on request and as part of the Annual Environmental Report required by condition (12).
- 12) The consent holder shall, not later than 30 September of each year after the plant is commissioned, provide an Annual Environmental Report to the Canterbury Regional Council setting out a summary of results, with analyses, and comments, as appropriate, of all requirements of this resource consent, including emission tests undertaken in relation to this consent over the previous processing season (from 1 July to 30 June inclusive). Where the result of any test undertaken in relation to this consent exceeds the relevant limit, then the steps that were taken (or proposed to be taken within a timeframe for implementation) to correct the exceedance shall be provided.



## 8.0 Conclusion

Having assessed the worst-case conditions with air discharges from the Proposed Site operations, PDP concludes that the activity is unlikely to result in adverse health effects at any of the sensitive receptors at or beyond the site boundary.

This is based on a conservative approach, which was taken in modelling the pollutants discharges, the site has been modelled with operating 24 hours a day, seven days a week at capacity.

The odour discharges from the scrubber and stack have been modelled separately using an odour discharge concentration of 500 OU/m<sup>3</sup> each. This is in line with data from other air discharge assessments on plants with a similar level of treatment.

The air dispersion modelling results predict that the maximum off-site combustion emission concentrations are below the relevant assessment criteria. Table 27 summarises the maximum cumulative ambient air concentration for the combustion pollutants relevant to this assessment against the relevant assessment criteria. It should be noted that the magnitude of change assessed only notes the degree of change and does not reflect the overall assessment of adverse effects on human health as all results are below the recommended guideline value<sup>36</sup>.

In conclusion, PDP considers the impact from the site operations has on the environment is unlikely to result in any adverse health effects beyond the site boundary.

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<sup>36</sup> For example, a more than minor magnitude of change does not result in a more than minor adverse human health effects.

Table 27: Summary of Combustion Emissions					
Pollutant	Period	Maximum Concentration (including background) ( $\mu\text{g}/\text{m}^3$ )	Relevant guideline ( $\mu\text{g}/\text{m}^3$ )	Percentage of guideline (%)	Magnitude of Change
NO <sub>2</sub>	1-hour	69.0	200	35%	Slight, Adverse: Less than Minor
	24-hour	47.6	100	48%	Slight, Adverse: Less than Minor
	Annual	3.7	10	37%	Negligible
SO <sub>2</sub>	1-hour	42.7	350	12%	Negligible
	24-hour	14.1	120	12%	Negligible
PM <sub>10</sub>	24-hour	11	50	22%	Negligible
	Annual	8.1	20	41%	Negligible
PM <sub>2.5</sub>	24-hour	4.7	25	19%	Negligible
	Annual	2.3	10	23%	Negligible
CO	1-hour	5,038	30,000	17%	Negligible
	8-hour	3,013	10,000	30%	Negligible
Antimony (Sb)	1-hour	0.04	1	4%	Negligible
	Annual	$2.9 \times 10^{-4}$	0.3	0%	Negligible
Arsenic	1-hour	0.01	9.9	0%	Negligible
	Annual	$5.7 \times 10^{-5}$	0.0055	1%	Negligible
Beryllium	Annual	$2.9 \times 10^{-4}$	0.02	1%	Negligible
Cadmium	1-hour	0.04	18	0%	Negligible
	Annual	$2.9 \times 10^{-4}$	0.005	6%	Negligible
Chromium VI	1-hour	0.04	1.3	3%	Negligible
	Annual	$2.9 \times 10^{-4}$	0.0011	26%	Slight, Adverse: Less than Minor
Cobalt	Annual	$2.9 \times 10^{-4}$	0.1	0%	Negligible
Copper	1-hour	0.04	100	0%	Negligible
	Annual	$2.9 \times 10^{-4}$	490	0%	Negligible

Table 27: Summary of Combustion Emissions					
Pollutant	Period	Maximum Concentration (including background) ( $\mu\text{g}/\text{m}^3$ )	Relevant guideline ( $\mu\text{g}/\text{m}^3$ )	Percentage of guideline (%)	Magnitude of Change
Lead	3-month	$3.7 \times 10^{-4}$	0.2	0%	Negligible
Manganese	1-hour	0.04	9.1	0%	Negligible
	Annual	$2.9 \times 10^{-4}$	0.15	0%	Negligible
Nickel	1-hour	0.04	1.1	4%	Negligible
	Annual	$2.9 \times 10^{-4}$	0.02	1%	Negligible
Selenium	Annual	$2.9 \times 10^{-4}$	20	0%	Negligible
Thallium	Annual	$1.2 \times 10^{-5}$	0.7	0%	Negligible
Tin	Annual	$2.9 \times 10^{-4}$	7000	0%	Negligible
Vanadium	1-hour	0.04	30	0%	Negligible
	Annual	$2.9 \times 10^{-4}$	0.1	0%	Negligible
Benzene	1-hour	7.6	580	1%	Negligible
	Annual	0.046	3.6	1%	Negligible
Xylene	1-hour	7.6	7,400	0%	Negligible
	Annual	0.06	200	0%	Negligible
Toluene	1-hour	7.6	15,000	0%	Negligible
	Annual	0.06	5,000	0%	Negligible
1,3,5- and 1,3,4-trimethylbenzene	1-hour	7.6	15,000	0%	Negligible
	Annual	0.06	60	0%	Negligible
Mercury	1-hour	0.01	0.6	2%	Negligible
	Annual	$1.1 \times 10^{-4}$	0.13	0%	Negligible
Ammonia	1-hour	7.6	590	1%	Negligible
	24-hour	0.06	320	0%	Negligible
Dioxin	Annual	$4.1 \times 10^{-9}$	$3.5 \times 10^{-6}$	0%	Negligible
Hydrogen Chloride	1-hour	4.5	660	1%	Negligible
	Annual	0.04	26	0%	Negligible
Hydrogen Fluoride	1-hour	0.8	60	1%	Negligible
	Annual	0.006	29	0%	Negligible



## Annual Wind Patterns

There are two meteorological stations located within Waimate that have not been included in the CALMET model owned by NIWA and ECan. PDP could not determine the location of the NIWA meteorological station based on the coordinates provided and aerial footage, therefore comparison to the ECan monitor has been undertaken.

Windrose frequency analyses of 1-hour average wind speed and direction observations at the Waimate ECan station for the full calendar years of 2019 to 2020 are illustrated in Figure A1. It should be noted that the Waimate monitor is approximately 6 m in height. The availability of wind data, frequency of calm conditions and average wind speeds measured from 2019 to 2020 are summarised in Table A1.

Table A1: Summary of wind measurements at Waimate 2019-2020		
Parameter	2019	2020
Wind data availability	75.06%	75.01%
Frequency of calm conditions (Less than 0.5 m/s)	4.01%	3.90%
Average wind speed	2.28 m/s	2.27 m/s

Wind directions in 2019 are more varied when compared to 2020 where the predominant wind occurred from the northwest. Both years show north-easterly winds being predominant followed by southwest and westerly wind. However, 2020 shows a lack of northly winds.

Both years had a similar data capture rate and a similar percentage of calms.

### Comparison between predicted and modelled wind conditions

Wind rose frequency analysis of 1-hour average wind speed and directions predicted at the site in 2019 and 2020 are compared with the wind observations by ECan in Waimate for the corresponding year in Figure A1.

As shown in Figure A1, predicted wind speed and direction patterns a high percentage of winds coming from the west and at higher windspeeds. This could be due to the ECan site being approximately 6 m in height and the CALMET dataset being 10 m. This would also explain the decrease in calms. Due to the site being 16 km southeast of Waimate, the wind conditions present at the site also need to be considered.

Overall, the meteorological predictions used in the dispersion modelling investigation are considered to be representative of wind conditions likely to be encountered in the area. With the predominant northeasterly and westerly winds being measured.

SOUTH ISLAND RESOURCE RECOVERY LIMITED - AIR QUALITY EMISSIONS ASSESSMENT - PROJECT KEA

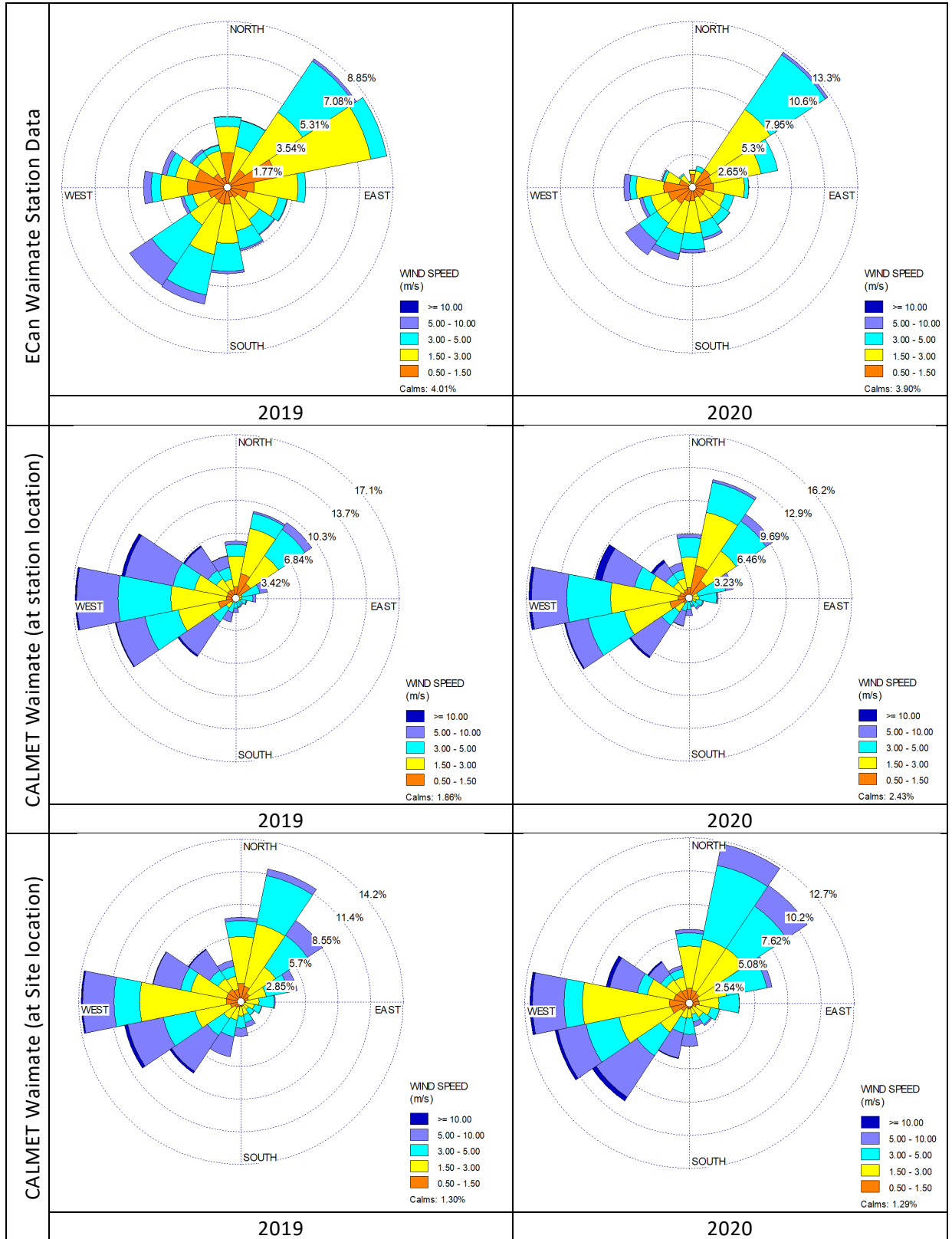
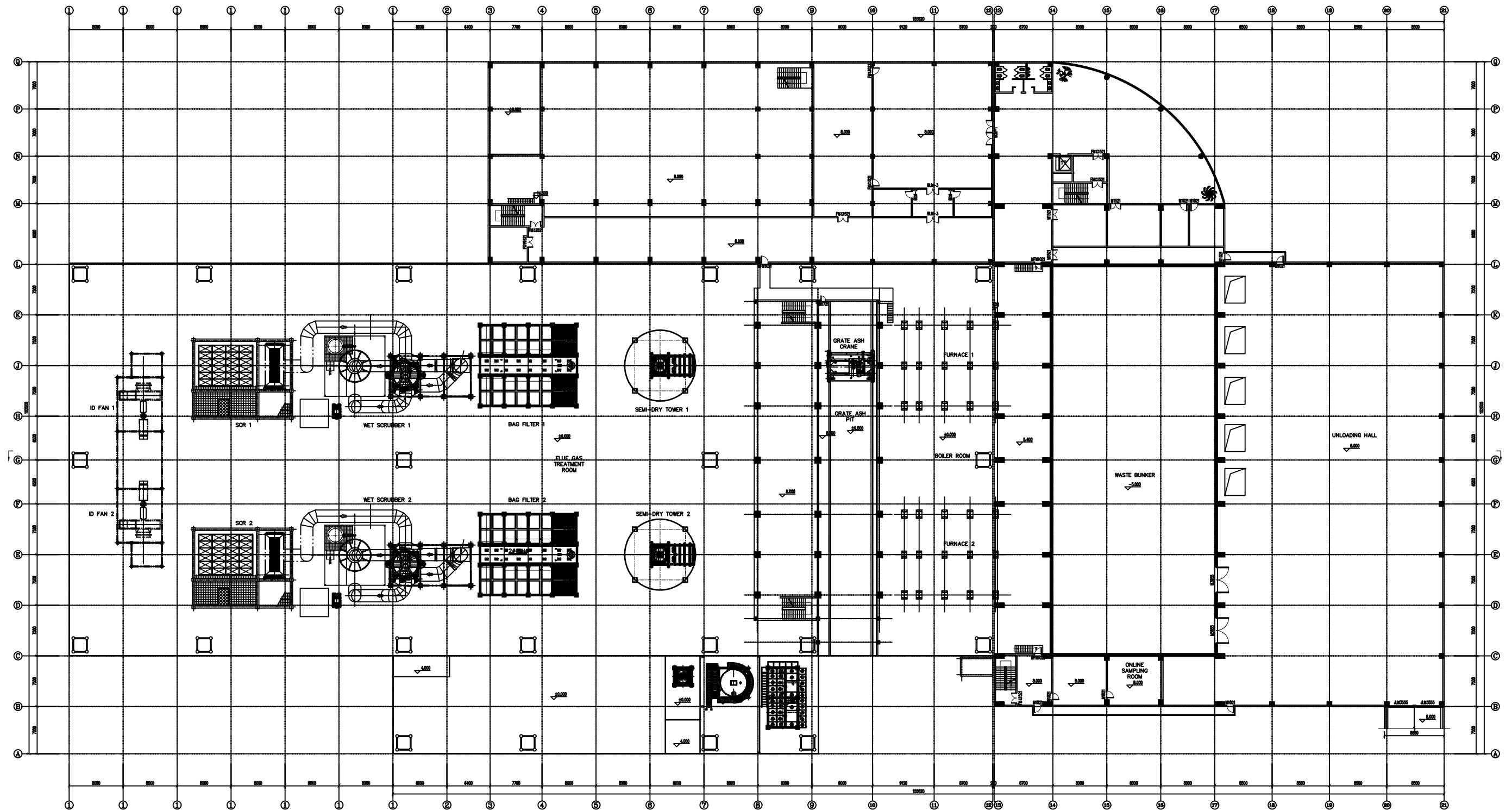


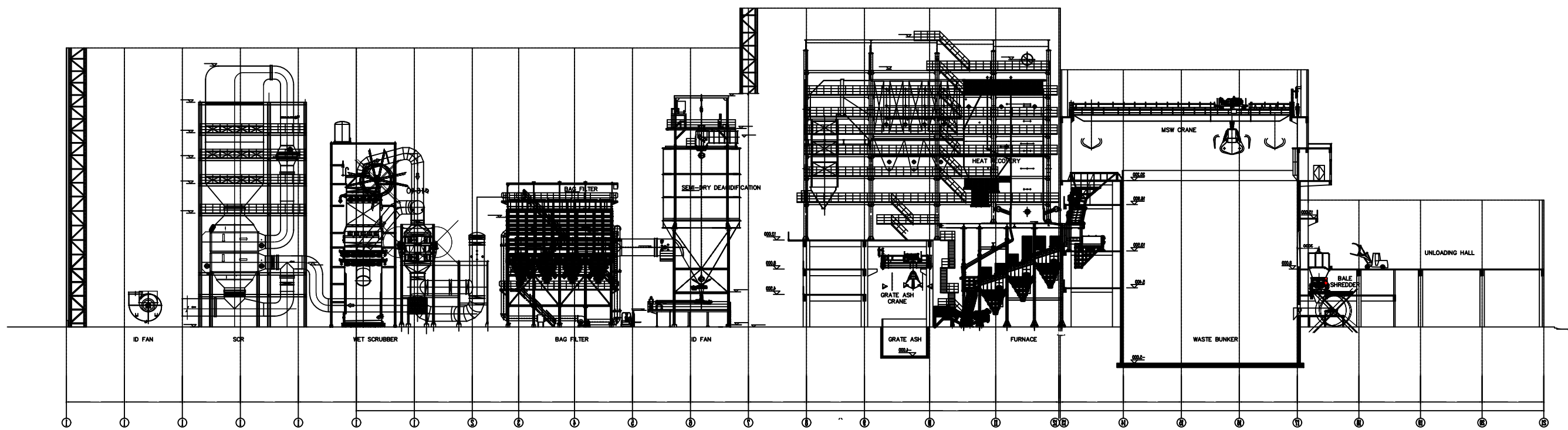
Figure A1: Annual observed Windrose analysis





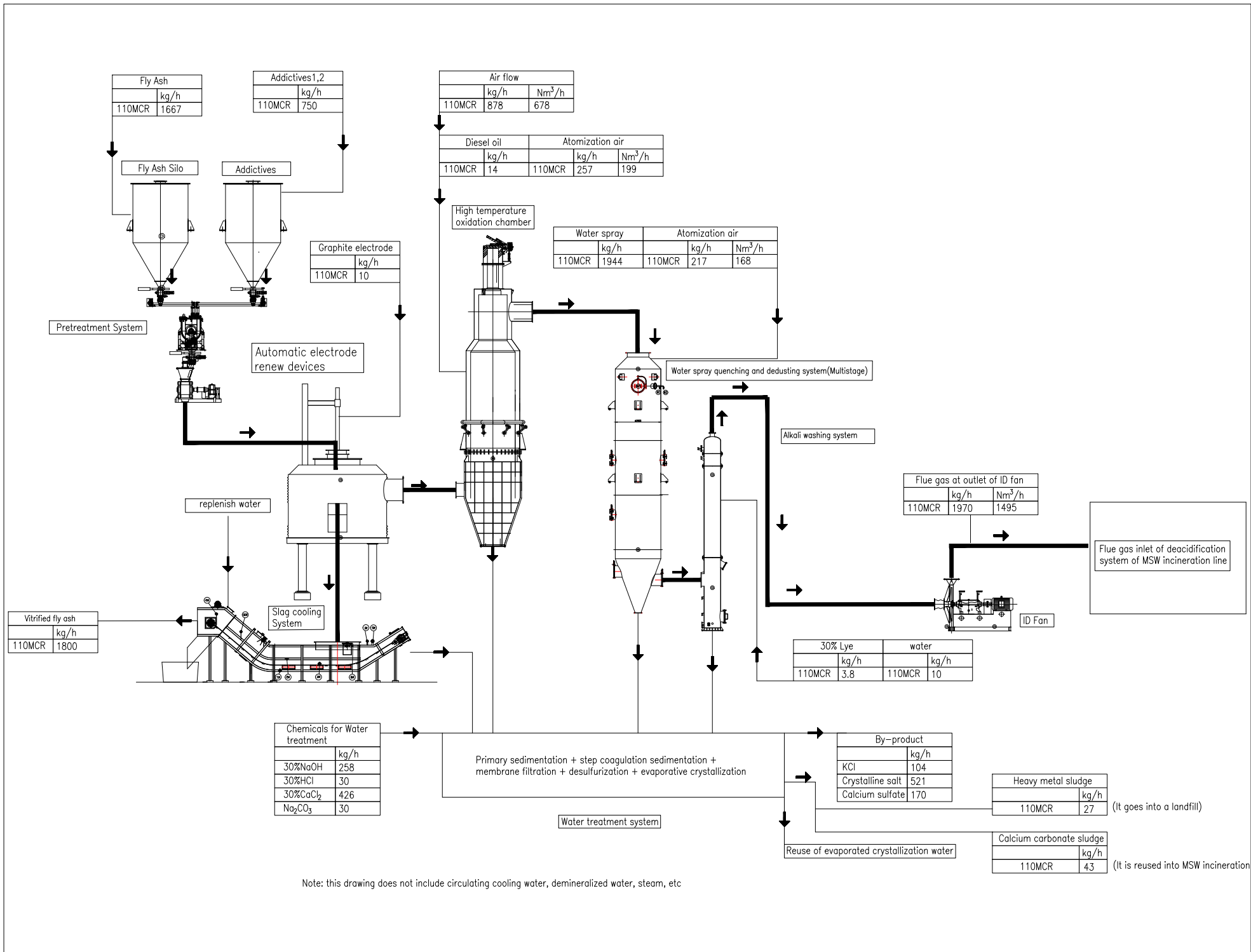
PROJECT KEA	1000TPD; WAIMATE; NEW ZEALAND	DWG NAME	EQUIPMENT LAYOUT RL8.0	DWG NO.	12
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PROJECT KEA	1000TPD; WAIMATE; NEW ZEALAND	DWG NAME	BOILER AND FLUE GAS TREATMENT	DWG NO.	13
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## **Appendix C: Acute and Chronic Health and Guideline Information**

From Appendix B of the HHRA

Table C1: Acute TRVs adopted in this assessment

Chemicals evaluated	Acute air guideline (1-hour average) (mg/m <sup>3</sup> )	Key health effects
<b>Gases</b>		
Hydrogen chloride (HCl)	0.66 (TCEQ 2015d)	HCl gas is a strong irritant, causing irritation of the eye, nose, and throat. Inhalation of HCl gas at sufficiently high concentrations can also produce acute tracheobronchitis (characterized by cough, sore throat, chest pain, and light-headedness); bronchoconstriction; and pulmonary oedema. Acute air guidelines is protective of all acute effects, with respiratory effects in individuals with asthma being the most sensitive effect (TCEQ 2015d).
Hydrogen fluoride (HF)	0.06 (TCEQ 2015b)	The upper respiratory tract is the most sensitive target of acute toxicity of F and HF exposure. HF gas is corrosive to the eyes and mucous membranes of the respiratory tract. Acute inhalation exposure to F or HF in humans has resulted in eye, nose and respiratory irritation, and inflammation of the airways. Exposure to high concentrations of HF can cause severe irritation, pulmonary oedema, pulmonary haemorrhagic oedema, tracheobronchitis, or death. The results of acute human and animal studies show that humans might be more sensitive than rats to the irritation effects of HF or F, approximately by an order of magnitude. Acute air guideline based on increased airway inflammation in human studies (TCEQ 2015b).
Ammonia	0.59 (TCEQ 2014a)	The available studies (occupational and experimental) indicate that acute exposure to low to moderate concentrations of ammonia (less than 100 ppm) can cause sensory irritation (discomfort in the eyes and/or nose) in humans but are not related to functional respiratory deficits. In general, the acute health effects reported in animals following short-term inhalation of ammonia include oral, nasal and eye irritation, respiratory tract irritation, decreased respiratory rate, increased respiratory depth, reduced body weight, and lethargy. In humans, the health effects of acute exposure are similar to those reported in animals and include oral, nasal and eye irritation, respiratory tract irritation, and increased respiratory depth. Effects on tissues and organs distant from the entry point have not been observed because of the scrubbing mechanism of the nasopharyngeal region. Ammonia is highly water soluble and as such readily dissolves in the mucous membrane layer of the cornea and upper airway. This "scrubbing" protects the lower respiratory tract and has been shown to be concentration and time dependent. Acute air guideline based on the most sensitive effects, namely mild, transient effects in respiratory system and CNS effects in human studies (TCEQ 2014a).
Benzene	0.58 (TCEQ 2015c)	The key health effects associated with exposure to benzene relate to chronic exposures. Both animal and human data indicate the most sensitive noncarcinogenic health effect of acute and chronic exposure is haematotoxicity (i.e. bone marrow depression: leukopenia, pancytopenia, granulocytopenia, lymphocytopenia, thrombocytopenia, aplastic anaemia) (TCEQ 2015c) as well as CSN excitation and depression and neurological effects. The acute air guideline is based on decreased lymphocytes in an animal study (TCEQ 2015c). The study used by TCEQ is the same adopted by ATSDR (ATSDR 2007b) in establishing their acute air guideline (noting the ATSDR review is more dated).
Toluene	15 (TCEQ 2013b)	The available studies indicate that acute inhalation exposures to toluene may result in CNS or neurotoxicity effects (including changes in reaction time, coordination, visual performance, dizziness, intoxication) as well as irritation to the eyes and respiratory tract (ATSDR 2000). The CNS is the most sensitive effect, with the acute air guideline based on the most recent review, with the most sensitive effects being CNS and irritation effects in human volunteers (TCEQ 2013b).

Chemicals evaluated	Acute air guideline (1-hour average) (mg/m <sup>3</sup> )	Key health effects
Xylenes	7.4 (TCEQ 2013b)	The available studies indicate that acute inhalation exposures to xylenes may result in CNS/neurological and respiratory effects. Irritation of the eyes, nose and throat may also occur. Neurological effects include fatigue, headache, dizziness, and a feeling of intoxication. The acute air guideline is based on the most recent review with the sensitive effects being mild respiratory and subjective neurological effects in human volunteers (TCEQ 2013b).
<b>Inorganics and organics bound to particulates (where acute effects are relevant)</b>		
Antimony	0.001 (ATSDR 2019a)	The most sensitive effects related to acute inhalation exposures to antimony have been identified as respiratory effects, with effects on the cardiovascular system less sensitive (ATSDR 2019a). Acute air guideline adopted is based on respiratory effects (epithelium effects at base of epiglottis) in an animal study (ATSDR 2019a).
Arsenic	0.0099 (TCEQ 2012)	Short-term exposures to arsenic have been reported to result in severe irritation to both the upper and lower parts of the respiratory system, followed by symptoms of cough, dyspnea, and chest pain. In addition, exposure to arsenic dust has been reported to cause laryngitis, bronchitis, and/or rhinitis. Further, exposure to arsenic via inhalation and/or ingestion can also cause gastrointestinal symptoms such as garlic-like breath, vomiting, and diarrhea. The available occupational and epidemiological studies have not identified developmental or reproductive effects; however these effects have been observed in animals but only at doses exceeding maternal toxicity. Acute air guideline adopted is based on the most sensitive effect, namely maternal effects in a reproductive study in animals.
Cadmium	0.018 (TCEQ 2016)	The toxicity of cadmium in air is dependent on the form of cadmium. The toxicity is higher with the more soluble cadmium compounds. Acute inhalation exposure to cadmium at concentrations may cause destruction of lung epithelial cells, resulting in decreased lung function, pulmonary oedema, tracheobronchitis, and pneumonitis in both humans and animals. Other effects identified in animal studies include decreased immune response, erosion of the stomach, decreased body weight gain and tremors (ATSDR 2012e). Acute air guideline is based on immunological effects in animals (most sensitive effect identified).
Chromium (Cr VI assumed)	0.0013 (TCEQ 2014b)	The assessment of chromium exposures has assumed that it comprises 100% chromium VI, which is the most toxic form of chromium. The toxicity is higher for soluble forms of Cr VI than insoluble forms. The respiratory system is the most sensitive health effect for both forms (TCEQ 2014b). Acute air guideline is based on respiratory effects (increased lung weight) in animals.
Copper	0.1 (OEHHA)	Copper is an essential element and hence health effects occur as a result of deficiency as well as toxicity. Acute inhalation value is based on occupational exposures to copper fume (unlikely to be representative of copper bound to particulates). In the absence of any other acute guidelines, this value has been conservatively adopted in this assessment.
Manganese	0.0091 (TCEQ 2017b)	Manganese is an essential element and hence health effects occur as a result of deficiency as well as toxicity. The neurological effects of inhaled manganese have been well documented in humans chronically exposed to elevated levels in the workplace. The syndrome known as "manganism" is caused by exposure to very high levels of manganese dusts or fumes and is characterized by a "Parkinson-like syndrome", including weakness, anorexia, muscle pain, apathy, slow speech, monotonous tone of voice, emotionless "masklike" facial expression and slow, clumsy movement of the limbs. In general, these effects are irreversible (WHO 2017). The most sensitive effect relevant to acute exposures, are respiratory effects. The acute air guideline is based on protection of respiratory effects in an animal study.

Chemicals evaluated	Acute air guideline (1-hour average) (mg/m <sup>3</sup> )	Key health effects
Mercury (as inorganic and elemental)	0.0006 (OEHHA)	This assessment has assumed that mercury in air comprises 100% elemental mercury vapour, which will result in a conservative assessment of inhalation exposures of inorganic mercury attached to particulates. Acute exposure to high concentrations of mercury vapour has been associated with chest pains, haemoptysis, breathlessness, cough and impaired lung function with the lung identified as the main target following acute exposure (ATSDR 1999). The central nervous system is generally the most sensitive indicator of toxicity of metallic mercury vapour. Data on neurotoxic effects are available from many occupation studies. Acute air guideline is based on protection of CNS effects in an animal study.
Nickel	0.0011 (TCEQ 2017a)	The respiratory system is the primary site of toxicity of inhaled nickel in both humans and laboratory animals. Effects seen in occupationally exposed workers include chronic bronchitis, emphysema, reduced vital capacity and asthma (UK EA 2009d). In relation to acute exposures respiratory effects are the most sensitive. The acute air guideline is based on protection of respiratory effects from an occupational study with nickel sulfate aerosols.
Vanadium	0.03 (OEHHA)	Data relevant to inhalation exposures to vanadium relate to vanadium pentoxide, with the most significant and most sensitive health effect identified as respiratory effects. The acute air guideline is based on the protection of these effects.

**References for health-based acute air guidelines (1-hour average):**

TCEQ = Acute reference exposure value (Acute ReV) available from the Texas Commission on Environmental Quality as referenced, also available from: <https://www.tceq.texas.gov/toxicology/dsd/final.html>

OEHHA = Guideline available from California Office of Environmental Health Hazard Assessment (OEHHA) <https://oehha.ca.gov/air/general-info/oehha-acute-8-hour-and-chronic-reference-exposure-level-rel-summary>

ATSDR = Guideline available from the Agency for Toxic Substances and Disease Registry (ATSDR), as an acute air guideline (relevant to exposures from 1 hour to 14 days) <https://www.atsdr.cdc.gov/mrls/index.html>

**Table C2: Summary of hazards – chronic exposures**

Pollutant evaluated	Summary of chronic health effects
<b>Gases</b>	
Hydrogen chloride (HCl)	<p>The key hazards associated with HF, relate to acute effects, where the respiratory system is the most sensitive health effect (refer to <b>Table B1</b>).</p> <p>Few human studies are available on the chronic effects of HCl exposure. Occupational studies have reported bleeding of the nose and gums and ulceration of the mucous membranes after repeated exposure to HCl mist at high (but unquantified) concentrations, work impairment and dental erosion following exposure to acid mists.</p> <p>IARC has not determined HCl not classifiable in relation to carcinogenicity. The available data does not support that HCl is carcinogenic.</p> <p>Chronic inhalation air guidelines are based on the most sensitive health effect, being hyperplasia of the nasal mucosa, larynx and trachea in animals (rat study) (TCEQ 2015d).</p> <p>Ambient or background levels of HCl in air are expected to be negligible.</p>
Hydrogen fluoride (HF)	<p>The key hazards associated with HF, relate to acute effects, where the respiratory system is the most sensitive health effect (refer to <b>Table B1</b>).</p> <p>In relation to chronic inhalation exposures, the key adverse health effects are skeletal fluorosis and respiratory effects. HF is not considered to be carcinogenic, with IARC and the USEPA not having evaluated carcinogenicity due to inadequate data. Some genotoxicity has been identified however only at doses that are highly toxic to cells (TCEQ 2015b).</p> <p>Chronic air guideline adopted is based on the most sensitive effect, namely skeletal fluorosis, based on an occupational study (TCEQ 2015b).</p> <p>Ambient or background levels of HCl in air are expected to be negligible (DEFRA 2008).</p>
Ammonia	<p>The key hazards associated with ammonia, relate to acute effects, where the respiratory and CNS systems are the most sensitive health effects (refer to <b>Table B1</b>).</p> <p>In relation to chronic exposures, there are few studies addressing long-term inhalation exposures to low concentrations. The key health effects identified in occupational studies relate to respiratory irritation, including cough, chest tightness, stuffy/runny nose, sneezing, phlegm, wheezing, dyspnea, chronic bronchitis, and asthma. Studies have shown acclimation of effects (ATSDR 2004a; TCEQ 2014a).</p> <p>Ammonia has not been classified as a human carcinogen and is not considered carcinogenic in animals.</p> <p>The chronic air guideline adopted is based on the most sensitive effect identified, namely respiratory effects (lung function) in and occupational study (TCEQ 2014a). The guideline adopted from TCEQ reflects the most current evaluation of effects and studies and is similar to the reference concentration available from the USEPA (USEPA IRIS).</p> <p>Ambient or background levels of ammonia (away from specific sources) in air are expected to be negligible, however it is noted that ammonia is produced endogenously (i.e. produced by the body). The studies used to develop the chronic air guideline are occupational studies and relate to an air concentration to which a range of individuals are exposed (where endogenous ammonia is already accounted for).</p>
Benzene	<p>Chronic exposure to benzene results primarily in haematotoxicity, including aplastic anaemia, pancytopenia, or any combination of anaemia, leukopenia, and thrombocytopenia. Chronic benzene exposure is associated with an increased risk of leukaemia. In chronic exposures, benzene metabolites are considered the toxic agents, not the parent compound. The relative contribution of different benzene metabolic pathways may be dose related, with more toxic agents produced by high affinity low capacity pathways (WHO 1993).</p> <p>Benzene is classified as a “known” human carcinogen (Category A) by the USEPA for all routes of exposure based upon convincing human evidence as well as supporting evidence from animal studies. IARC has classified benzene in Group 1 (known human carcinogen) (IARC 2012c; USEPA 2005b, 2005a). Benzene is carcinogenic via oral and inhalation routes of exposure (ATSDR 2007b; IARC 2012c; UK EA 2009c; WHO 1993) indicates that the overall results of available studies show that it is appropriate to consider benzene (and/or its metabolites) as genotoxic (though the genotoxic profile is considered unusual (Baars et al. 2001)).</p> <p>The assessment of benzene toxicity needs to consider carcinogenic effects where a non-threshold dose-response approach is appropriate.</p> <p>New Zealand (MfE 2002) has established a chronic air guideline value (based on an annual average) for benzene of 10 µg/m<sup>3</sup>, with a lower value of 3.6 µg/m<sup>3</sup> to be achieved by 2010. For this assessment the lower value of 3.6 µg/m<sup>3</sup> of 0.0036 mg/m<sup>3</sup> has been adopted. This guideline value is based on precautionary guideline values from Europe and the UK and are protective of carcinogenic effects. This air guideline is consistent with air guidelines derived on the basis of a non-threshold approach to assess carcinogenicity from TCEQ and the WHO (TCEQ 2015c; WHO 2000d). As the guideline is based on a non-threshold approach background intakes do not need to be accounted for.</p>



Pollutant evaluated	Summary of chronic health effects
Toluene	<p>The key health effects associated with inhalation exposures to toluene relate to the CNS (headaches, dizziness, and impaired neurobehavioral performance), kidneys, liver, respiratory system and reproduction.</p> <p>Toluene is classified by IARC and the US EPA as not classifiable as to human carcinogenicity due to inadequate evidence of carcinogenicity.</p> <p>Review of available data (Baars et al. 2001; UK EA 2009e; USEPA 2005c; USEPA IRIS; WHO 2011b) suggest that toluene has not been demonstrated to be genotoxic. On the basis of the available information, it is considered appropriate that a threshold dose-response approach be adopted for toluene.</p> <p>Toluene exposures have been assessed on the basis of the chronic inhalation air guideline from the USEPA (USEPA 2005c) which is similar to the more recent evaluation from TCEQ (TCEQ 2013b). Background or ambient concentrations of toluene are negligible compared with the chronic air guideline adopted.</p>
Xylenes	<p>Health effects of mixed xylenes, o-xylene, m-xylene and p-xylene, appear to be similar, although the individual isomers are not necessarily equal in potency with respect to a particular effect. Studies indicate that the central nervous system (CNS) is a major and sensitive target of xylene toxicity via inhalation and oral routes. The primary target organs following chronic oral and inhalation exposures are likely to be the CNS and development. Some studies indicate enlargement of the liver and kidneys following oral exposure to mixed xylene. Other target organs identified following inhalation exposure include the respiratory system, altered haematological parameters, nose and throat irritation.</p> <p>Xylene is classified by IARC and the US EPA as not classifiable as to human carcinogenicity due to inadequate evidence of carcinogenicity. The available studies suggest that xylenes are not considered genotoxic (UK EA 2009h; USEPA IRIS; WHO 1997). On the basis of the available information, it is considered appropriate that a threshold dose-response approach be adopted for xylenes.</p> <p>Xylenes exposures have been assessed on the basis of the chronic inhalation guideline from ATSDR (ATSDR 2007c), which is consistent with evaluations provided by the UK, TCEQ and USEPA (TCEQ 2013a; UK EA 2009h; USEPA 2003). Background or ambient concentrations of xylenes are negligible compared with the chronic air guideline adopted.</p>
Trimethylbenzene	<p>Trimethylbenzenes comprise 1,2,4-trimethylbenzene and 1,3,5-trimethylbenzene, both of which are aromatic petroleum hydrocarbons, which have health effects consistent with other aromatic hydrocarbons noted above (toluene and xylenes). The key adverse health effects associated with inhalation exposures are CNS and respiratory effects. Other effects include liver effects and anaemia.</p> <p>Neither the US EPA nor IARC has classified trimethylbenzene with respect to carcinogenicity and the limited data available on genotoxicity shows negative results. On the basis of the available information, it is considered appropriate that a threshold dose-response approach be adopted for trimethylbenzenes.</p> <p>Trimethylbenzene exposures have been assessed on the basis of the inhalation guideline established by the USEPA (USEPA 2016a), which applies to the sum of trimethylbenzenes, and is the most recent detailed review available which also provides a more conservative approach than TCEQ (TCEQ 2015a). The available data suggests background or ambient concentrations contribute around 10% of the adopted toxicity reference values.</p>
<b>Inorganics and organics bound to particulates (refer to Section B4 for additional detail)</b>	
Antimony	<p>Antimony in one of the oldest known remedies used in medicine. Data on side effects and toxicity of antimony and compounds have identified that the most sensitive effects relate to the respiratory tract, heart, gastrointestinal tract, serum glucose, and developmental effects.</p> <p>The International Agency for Research on Cancer (IARC 2015) categorized antimony trioxide in group 2B (possibly carcinogenic to humans) and antimony trisulfide in group 3 (not classifiable as to its carcinogenicity to humans). The EPA have not classified the carcinogenicity of antimony.</p> <p>In relation to chronic exposures, the most sensitive health effects identified relate to the respiratory system (inhalation exposures); and the gastrointestinal tract, liver, and serum glucose levels (oral exposures).</p> <p>The chronic air guideline adopted in this assessment is based on respiratory effects (lung inflammation) in animals from ATSDR (ATSDR 2019a), noting no other chronic inhalation guidelines are available.</p> <p>Oral (and dermal) exposures have been assessed on the basis of the tolerable daily intake adopted by the NHMRC and WHO in deriving drinking water guidelines (NHMRC 2011 updated 2022; WHO 2017).</p> <p>Background intakes of antimony are assumed to be 20% for oral and dermal exposures and negligible for inhalation exposures.</p>

Pollutant evaluated	Summary of chronic health effects
Arsenic	<p>Arsenic is a known human carcinogen, based on human epidemiological studies that show skin and internal cancers (in particular bladder, liver and lung) associated with chronic exposures to arsenic in drinking water. The International Agency for Research on Cancer (IARC) has classified arsenic and inorganic arsenic compounds as Group 1 'carcinogenic to humans' (IARC 2012b).</p> <p>The mechanism of action in relation to carcinogenicity is not clear and remains debated (IARC 2012b; Sams et al. 2007), with the weight of evidence indicating that a threshold approach is appropriate, noting effects on DNA occur through indirect mechanisms and at high levels of exposure.</p> <p>However due to uncertainties relating to the mechanism of action New Zealand has adopted a non-threshold approach to the assessment of all exposures to arsenic. On this basis the recommended TRV values from MfE (MfE 2002, 2011a), derived to be protective of the most sensitive effect, carcinogenicity using a non-threshold approach and 1 in 100,000 risk have been adopted in this assessment. Background intakes are not relevant to include where a non-threshold approach is adopted.</p>
Beryllium	<p>Occupational exposure to beryllium has been associated with acute and chronic lung diseases. Chronic disease is associated with long-term inhalation exposures to dust particles containing beryllium, has an immunological component and a latent period which varies depending on the beryllium species.</p> <p>The inhalation data led the International Agency for Research on Cancer to conclude that beryllium and beryllium compounds are carcinogenic to humans (Group 1, sufficient evidence of carcinogenicity in humans and sufficient evidence in animals) (IARC 1993). The USEPA has classified beryllium as B1 – probable human carcinogen. The WHO (WHO 2001c) also classified beryllium as carcinogenic based on occupational inhalation studies.</p> <p>Further review of genotoxicity by IARC (IARC 2012a) indicates that the evidence for mutagenic activity was weak or negative, however review of the available studies indicates that the underlying mechanism for carcinogenesis is complex and likely to involve several possible interactive mechanisms. Hence the evidence for a genotoxic mode of action is not clear, however there may be some mechanisms that relate to genotoxicity that affect carcinogenicity. Based on the available data carcinogenic effects of inhaled beryllium in non-occupational environments are not genotoxic and a threshold can be adopted.</p> <p>There is, however, no clear evidence that the compounds are carcinogenic when administered orally. Beryllium was not mutagenic in tests with different strains of bacteria but caused chromosomal aberrations and gene mutations in cultured mammalian cells. Hence a threshold is adopted for the assessment of oral exposures.</p> <p>Oral (and dermal) exposures have been assessed on the basis of the tolerable daily intake adopted by the NHMRC and WHO in deriving drinking water guidelines (NHMRC 2011 updated 2022; WHO 2017).</p> <p>Inhalation exposures have been assessed on the basis of the value from the WHO and USEPA (USEPA 1998b; WHO 2001c). <u>Background or ambient intakes are considered to be negligible.</u></p>
Cadmium	<p>Numerous studies examining the toxicity of cadmium in workers have identified the respiratory tract, the kidney and bone as sensitive targets of toxicity. Other effects identified include developmental and reproductive effects, hepatic effects, haematological effects and immunological effects (ATSDR 2012e).</p> <p>IARC has classified cadmium and cadmium compounds as a Group 1 agent (i.e., carcinogenic to humans) based on additional evidence of carcinogenicity in humans and animals. The USEPA has classified cadmium as a probable human carcinogen via inhalation. There is conflicting data on the genotoxicity of cadmium.</p> <p>Based on the available information assessment of oral and dermal exposures has adopted the threshold toxicity value from the WHO (WHO 2010b) which is consistent with the approach and value adopted by the NHMRC (NHMRC 2011 updated 2022).</p> <p>Sufficient data is available to conclude cadmium is carcinogenic via inhalation exposures. The inhalation air guideline adopted WHO 2000) is based on the most sensitive effect, namely kidney toxicity, which is also protective of carcinogenic effects.</p> <p><u>Background or ambient intakes have also been considered (where relevant).</u></p>
Chromium (Cr VI assumed)	<p>The assessment of chromium exposures has assumed that it comprises 100% chromium VI, which is the most toxic form of chromium.</p> <p>In the environment Cr VI less toxic form Cr III in the presence of oxidizable organic matter and hence assuming that Cr VI remains following long-term deposition to land is highly conservative. It is more likely to be present as Cr III.</p> <p>Cr VI is unstable in the body and is reduced to Cr V, Cr IV and ultimately to Cr III by many substances, including ascorbate and glutathione. It is believed that the toxicity of Cr VI compounds results from damage to cellular components during this process (WHO 2013).</p>

Pollutant evaluated	Summary of chronic health effects
	<p>Chronic exposure to Cr VI via inhalation has been found (in occupational studies) to result in respiratory tract and eye irritation, and cancer (respiratory tract and lung cancer) (WHO 2013). Oral exposures to Cr VI can cause gastrointestinal effects (most sensitive) and haematological effects. Oral exposures have not demonstrated an association with cancer in humans, however animal studies have shown carcinogenic potential. Dermal exposure to Cr VI can result in ulcers and allergic contact dermatitis (WHO 2013).</p> <p>IARC (IARC 2012b) has classified Cr VI compounds as Group 1 carcinogens: carcinogenic to humans. Chromium is classified by the US EPA as a Group A: known human carcinogen by the inhalation route, with carcinogenicity by the oral route of exposure noted to be Group D: not classified (USEPA 1998a).</p> <p>Assessment of oral and dermal exposures is undertaken on the basis of a threshold (noting limited data to support carcinogenicity), where the current value from ASTDR (ATSDR 2012d) is most appropriate, and more conservative than the value identified in the older review from MfE (MfE 2011a)</p> <p>Inhalation exposures need to be assessed on the basis of data that is protective of noncarcinogenic and carcinogenic effects, with a non-threshold approach relevant for the assessment of carcinogenic effects. The ambient air guideline from MfE (MfE 2002), which is similar to the more recent review from TCEQ has been adopted. This guideline is protective of all effects, which are dominated by the assessment of carcinogenicity (using a non-threshold approach).</p> <p>Background or ambient intakes are only relevant for oral and dermal exposures, where 10% has been adopted.</p>
Cobalt	<p>Indicators of adverse health effects in humans, cardiomyopathy and decreased iodine uptake by the thyroid. Cobalt is a sensitizer in humans by any route of exposure. Sensitized individuals may react to inhalation of cobalt by developing asthma; ingestion or dermal contact with cobalt may result in development of dermatitis. Respiratory effects, including respiratory irritation, wheezing, asthma, pneumonia and fibrosis, have been widely reported in humans exposed to cobalt by inhalation. Epidemiology studies show decreased pulmonary function in workers exposed to inhaled cobalt (USEPA 2008).</p> <p>IARC has classified cobalt metal, cobalt sulphate and other soluble cobalt (II) salts as Group 2B: possible human carcinogen. The USEPA has determined cobalt sulfate (soluble) is described as "likely to be carcinogenic to humans by the inhalation route". The available data, however suggests a non-genotoxic mechanism for carcinogenicity.</p> <p>Oral and dermal exposures have been assessed on the basis of a threshold value from the RIVM (Baars et al. 2001) while inhalation exposures have been assessed on the basis of the evaluation from the WHO (WHO 2006a) which is considered protective of all adverse health effects. Background or ambient intakes have also been considered.</p>
Copper	<p>Copper is an essential element and as such adverse effects may occur as a result of deficiency as well as excess intakes resulting from contamination.</p> <p>Liver and gastrointestinal effects are the most sensitive health effects from exposure to high levels of copper (ATSDR 2022; MfE 2011a), particularly in sensitive subpopulations.</p> <p>Copper is not considered to be carcinogenic.</p> <p>Exposure to copper has been evaluated on the basis of a toxicity reference value derived from a tolerable upper limit, with background intakes determined on the basis of information on dietary intakes (the key source of copper exposure).</p>
Lead	<p>The key health effects associated with exposure to lead are chronic.</p> <p>There is a large amount of information available about the health effects of lead, with information and data from epidemiological studies being the major lines of evidence. The health effects of lead are the same regardless of the route of exposure (ATSDR 2019b).</p> <p>Health effects associated with exposure to inorganic lead and compounds include, but are not limited to: neurological, renal, cardiovascular, haematological, immunological, reproductive, and developmental effects. Neurological effects of Pb are of greatest concern because effects are observed in infants and children and may result in life-long decrements in neurological function. The most sensitive targets for lead toxicity are the developing nervous system in children; and effects on the haematological and cardiovascular systems, and the kidney in adults.</p> <p>However, due to the multi-modes of action of lead in biological systems, lead could potentially affect any system or organs in the body. The effects of lead exposure have often been related to the blood lead content, which is generally considered to be the most accurate means of assessing exposure (MfE 2011a).</p> <p>Children and pregnant women are particularly sensitive to lead exposure, and low lead exposure studies have focused on a range of health outcomes including on neurological (such as cognitive and behavioural functioning), cardiovascular and reproductive and developmental health endpoints (Armstrong et al. 2014).</p>

Pollutant evaluated	Summary of chronic health effects
	<p>The International Agency for Research on Cancer (IARC 2006) has classified inorganic lead as Group 2A: probably carcinogenic to humans.</p> <p>While it is appropriate to utilise a blood lead model to evaluate exposure to lead, toxicity reference values have been developed using blood lead models that are protective of adverse health effects with changes in IQ identified as the most sensitive effect by MfE (MfE 2011a). The threshold value adopted from MfE is consistent with intakes determined to be protective of IQ effects in children based on blood lead modelling and are considered appropriate. Inhalation exposures have been assessed on the basis of the air guideline from MfE (MfE 2002). This assessment has adopted these values as well as information of background lead exposures (principally from the diet).</p>
Manganese	<p>Manganese is an essential element and hence health effects occur as a result of deficiency as well as toxicity. Exposures via inhalation have the potential to result in respiratory effects as well as neurological effects. By the oral route, manganese is regarded as one of the least toxic elements, however there is some concern that the neurological effects observed from inhalation exposures also occur with oral exposures.</p> <p>Manganese is not considered to be carcinogenic.</p> <p>The chronic inhalation guideline is based on based on protection of neurological effects. The oral value is based on a tolerable upper intake for the element, with background intakes considered (principally from the diet).</p>
Mercury (as inorganic and elemental)	<p>This assessment has assumed that mercury in air comprises 100% elemental mercury vapour, which will result in a conservative assessment of inhalation exposures of inorganic mercury attached to particulates.</p> <p>The central nervous system is generally the most sensitive indicator of toxicity of metallic mercury vapour. Data on neurotoxic effects are available from many occupation studies. Chronic exposure to metallic mercury may result in kidney damage with occupational studies indicating an increased prevalence of proteinuria.</p> <p>Elemental and inorganic mercury are not considered to be carcinogenic.</p> <p>Inhalation exposures have been assessed on the basis of a toxicity value from the WHO (WHO 2003) based on the protection of CNS effects. The value is consistent with guidance from other organisations including New Zealand MfE (MfE 2002).</p> <p>Oral and dermal exposures have assumed the form of mercury in the environment is inorganic mercury, where the kidney is the key health effect. Other health effects identified in relation to inorganic mercury include neurological effects and reproductive and developmental effects. Oral and dermal exposures have been assessed on the basis a tolerable daily intake recommended by MfE, WHO and ATSDR, with background intakes considered.</p>
Nickel	<p>The respiratory system is the primary site of toxicity of inhaled nickel in both humans and laboratory animals. Nickel and compounds have been established as carcinogenic via inhalation and the compounds are generally considered to be genotoxic, however the mechanism of action is not well understood. An air guideline has been adopted that is protective of all adverse health effects, including noncarcinogenic and carcinogenic (based on a linear/non-threshold approach) effects. The most sensitive health effects relate to respiratory effects and lung cancer.</p> <p>Nickel is a potent skin sensitiser and ingestion of nickel can result in skin reactions in sensitised individuals. Other health effects associated with ingestion include the potential for kidney and developmental effects. There is no substantial evidence that nickel is carcinogenic via oral or dermal exposures and hence these exposures are assessed on the basis of a threshold toxicity value that is protective of all adverse health effects. Background intakes have been considered where relevant.</p>
Selenium	<p>Selenium is an essential element for many species, including humans, hence health effects may occur as a result of deficiency as well as toxicity. Exposure to elevated levels of selenium can result in brittle hair and deformed nails, CNS effects, gastrointestinal disturbances, dermatitis and dizziness.</p> <p>Selenium is not considered to be carcinogenic.</p> <p>Assessment of exposure to selenium has been undertaken on the basis of a threshold that is based on an upper tolerable limit from the diet, accounting for background intakes (predominantly via the diet).</p>
Thallium	<p>Thallium is a highly toxic trace element. Acute (non-fatal) exposures have the potential to cause gastrointestinal effects, with alopecia occurring within 2 weeks of elevated exposures, Chronic exposures include hair loss, neurological effects (the most significant adverse health effect), as well as polyneuritis, encephalopathy, tachycardia and degenerative changes of the heart, liver and kidneys. While limited data is available thallium has not been determined to be carcinogenic. There are limited studies available to establish quantitative toxicity reference values. All available values are based on the same key study, with the value adopted by RIVM (Janssen et al. 1998) and recommended following more recent review (Pearson &amp; Ashmore 2020) adopted, with background intakes also considered.</p>

Pollutant evaluated	Summary of chronic health effects
Tin	<p>There is limited information available in relation to tin, however inorganic tin is considered to be of low toxicity. The main route of exposure to tin is via food, in particular canned food. health effects may include gastrointestinal effects, anaemia and effects on the liver and kidney (ATSDR 2005b). Inorganic tin compounds are not considered carcinogenic (ATSDR 2005b). Exposure to tin has been assessed on the basis of a threshold toxicity value from RIVM (Tiesjema &amp; Baars 2009) that is lower than the JECFA guideline for safe levels of tin in food. Background intakes are considered.</p>
Vanadium	<p>Vanadium exposures have the potential to result in respiratory effects along with gastrointestinal effects, haematological effects and reproductive effects. Most of the available data on this compound relates to vanadium pentoxide which is considered to have carcinogenic potential. For other vanadium compounds (more likely to be present) the carcinogenic potential is not known. Assessment of chronic oral and dermal exposures has adopted available and relevant toxicity values protective of all adverse health effects for vanadium compounds. Assessment of chronic inhalation exposures has adopted the most current guideline value for vanadium pentoxide. Background intakes of vanadium are expected to be negligible.</p>
Dioxins and furans	<p>Dioxins and furans are widely present in the environment, some occurring naturally but most as unwanted by-products of combustion. These compounds are persistent and accumulate in the body. Human exposure to dioxins and dioxin-like substances has been associated with a range of toxic effects, including chloracne; reproductive, developmental and neurodevelopmental effects; immunotoxicity; and effects on thyroid hormones, liver and tooth development. Dioxins are also carcinogenic with IARC classifying them as Group 1. Developmental effects in males are the most sensitive reproductive health end-point, making children, particularly breastfed infants, a population at elevated risk. Dioxins and furans, however are not considered to be genotoxic. In addition, the dose required to result in carcinogenic effects is greater than the dose required for more sensitive effects such as developmental and reproductive effects. Dioxin-like compounds are listed on the Stockholm Convention on Persistent Organic Pollutants. The assessment of exposure, from all pathways, has been undertaken on the basis of a threshold toxicity value established by the Ministry of Health (MfE 2011a), which is more conservative than the value adopted by the NHMRC (NHMRC 2002) and WHO (FAO/WHO 2018; WHO 2019). Background intakes relevant to New Zealand have been considered.</p>



**Table C3: Summary of chronic TRVs adopted for chemicals**

Chemical	Inhalation TRV (mg/m <sup>3</sup> )	Oral/dermal TRV (mg/kg/day)	GI absorption factor*	Dermal absorption*	Background intakes (as percentage of TRV)	
					Oral/dermal**	Inhalation**
Hydrogen chloride (HCl)	0.026 <sup>T</sup>	NA (gaseous chemical)			NA	0%
Hydrogen fluoride (HF)	0.029 <sup>T</sup>	NA (gaseous chemical)			NA	0%
Ammonia	0.32 <sup>T</sup>	NA (gaseous chemical)			NA	0%
Benzene	0.0036 <sup>NZ</sup>	NA (gaseous chemical)			NA	0%
Toluene	5 <sup>U</sup>	NA (gaseous chemical)			NA	0%
Xylenes	0.2 <sup>A</sup>	NA (gaseous chemical)			NA	0%
Trimethylbenzene	0.06 <sup>U</sup>	NA (gaseous chemical)			NA	10%
Antimony	0.0003 <sup>A</sup>	0.00086 <sup>W</sup>	15%	0	20%	0%
Arsenic	0.0000055 <sup>NZ</sup>	0.0000086 <sup>NZ</sup>	100%	0.005	0%	0%
Beryllium	0.00002 <sup>W</sup>	0.002 <sup>W</sup>	0.7%	0	0%	0%
Cadmium	0.000005 <sup>W</sup>	0.0008 <sup>W, NZ</sup>	100%	0	50%	20%
Chromium (Cr VI assumed)	0.0000011 <sup>NZ</sup>	0.003 <sup>NZ</sup>	100%	0	0%	0%
Copper	0.49 <sup>R</sup>	0.14 <sup>W, NZ</sup>	100%	0	33%	33%
Cobalt	0.0001 <sup>W</sup>	0.0014 <sup>D</sup>	100%	0	20%	0%
Lead***	0.0002 <sup>NZ</sup>	0.0019 <sup>NZ</sup>	100%	0	50%	0%
Manganese	0.00015 <sup>W</sup>	0.16 <sup>A</sup>	4%	0	50%	20%
Mercury (as inorganic and elemental)	0.0002 <sup>W</sup>	0.002 <sup>NZ</sup>	7%	0.001	5%	5%
Nickel	0.00002 <sup>E</sup>	0.012 <sup>W</sup>	100%	0.005	60%	20%
Thallium	0.0007 <sup>R</sup>	0.0002 <sup>D1</sup>	100%	0	80%	80%
Vanadium	0.0001 <sup>A</sup>	0.002 <sup>D</sup>	2.6%	0	0%	0%
Selenium	0.02 <sup>O</sup>	0.006 <sup>N1</sup>	100%	0	0%	0%
Tin	7 <sup>R</sup>	2 <sup>W</sup>	100%	0	0%	0%
Dioxin-like chemicals assumed to be WHO <sub>05</sub> TEQs	3.5E-09 <sup>R</sup>	1E-09 <sup>NZ</sup>	100%	0.03	33%	33%

**Notes**

\* GI factor and dermal absorption values adopted from RAIS (accessed in 2022) (RAIS)

\*\* Background intakes relate to intakes from inhalation, drinking water and food products. The values adopted are based on information available for New Zealand, where available or international data. Gaseous chemical background intakes are not known and hence for this assessment they have been assumed to be negligible

\*\*\* Inhalation exposures to lead have been evaluated on the basis of the ambient air guideline of 0.0002 mg/m<sup>3</sup> for a 3-month average (MfE 2002), which has been assumed to also apply as an annual average (refer to main report for discussion)

R = No inhalation-specific TRV available, hence inhalation exposures assessed on the basis of route-extrapolation from the oral TRV, as per USEPA guidance (USEPA 2009d)

NZ = New Zealand ambient air guideline (MfE 2002) for annual average exposures, adopted where this is more conservative than the most current health based guideline relevant to the assessment of chronic health effects; or NZ toxicological value used in the derivation of soil guideline values (MfE 2011a). For benzene, arsenic and chromium the TRVs adopted are based on protection of carcinogenic effects based on a non-threshold (linear) approach and adoption of 1 in 100,000 risk level. For these chemicals and calculations, it is not relevant to include background intakes as the calculation relates to an incremental lifetime risk

T = TRV available from TCEQ, relevant to chronic inhalation exposures (and HI=1) (TCEQ 2012, 2013c, 2014a, 2015d, 2015b)

A = TRV available from ATSDR, relevant to chronic intakes (ATSDR 2007c, 2012a, 2012c, 2012b, 2019a)

D = TRV available from RIVM (Baars et al. 2001; van Vlaardingen, Posthumus & Posthuma-Doodeman 2005), D1 relates to the values adopted for thallium which are consistent with those recommended, and based on diet surveys in New Zealand (Pearson & Ashmore 2020)

E = TRV available from the UK Environment Agency (UK EA 2009d) for nickel, noting this value is protective of all adverse effects including carcinogenicity

O = TRV from OEHA, as chronic reference exposure level (REL) (OEHA)

N1 = TRV for selenium based on the upper intake limit for selenium in food and supplements as determined by NHMRC and MoH (NHMRC 2006)

U = TRV available from the USEPA IRIS (current database) (USEPA IRIS)

W = TRV available from the WHO, relevant to chronic inhalation exposures (WHO 1999, 2000c, 2006a, 2017), noting inhalation value adopted for mercury is for elemental mercury (WHO 2003) which is lower than the NZ ambient air quality guideline (MfE 2002)





## TAPM Prognostic Model

TAPM predicts all meteorological parameters for the region based on large-scale synoptic information provided by the Australian Bureau of Meteorology.

In order to produce the meteorological data set to run CALPUFF, TAPM was configured with:

- ∴ Four nested meteorological grids with a grid spacing of 30, 10, 3, 1 km;
- ∴ Default vegetation, topography and soil types as supplied in the TAPM databases for New Zealand;
- ∴ Grid Centre at UTM 508,671 m E, 5,028,025 m S UTM Zone 60H;
- ∴ Deep soil moisture used was 0.15;
- ∴ Grid dimensions (nx, ny, nz) = 41, 41, 35;
- ∴ Prognostic turbulence scheme and hydrostatic approximation.
- ∴ No observational data was added to this dataset as those were included in the CALMET Model; and.
- ∴ Meteorological dataset was extracted from the model which was converted to a .dat file from the M3D file that TAPM produces. This file was used to input to CALMET.

PDP has used TAPM as a high-level model, providing upper air data for CALMET. Surface station observations were not included in the TAPM model as they have been added into the CALMET model. PDP has chosen to input the surface station observations in the CALMET model, as opposed to TAPM, as this enables more parameters to be included. Essentially, PDP has used TAPM to generate the upper air data and the ground level data is generated in CALMET through the surface station observations.

## CALMET Prognostic Model

Observational station data was added into the CALMET model from eight meteorological datasets. The datasets used are provided in Table D1. The default terrain file (SRMT3), and the default land use file (GLCC Australia Pacific ~1km) were used to generate the CALMET model to a mesh density of eight. The surrounding area has no significant land use features that would impact dispersion, therefore, the default values are deemed suitable.

Table D1: Climate stations used in CALMET Dataset			
Model ID	Station Name	Operating Authority	Parameters Measured
4843	Christchurch Airport	NIWA	WS, WD, T, RH, P, rain Ccover, Cheight
36209	Hakataramea	NIWA	WS, WD, P, rain
40986	Oamaru (Town)	NIWA	WS, WD, T, RH, P, rain
937960	Oamaru	MetService	WS, WD, T, RH, P
43845	Otaio	N/A	WS, WD, T, RH, P, rain
937470	Tara Hills	MetService	WS, WD, T, RH, P
937730	Timaru	MetService	WS, WD, T, RH, P
18594	Windsor	NIWA	WS, WD, T, RH, P, rain

Notes:

1. WS = Wind Speed, WD = Wind Direction, T = Temp, RH = Relative Humidity, P = Pressure, Ccover = Cloud Cover, Cheight = Cloud Height

The stations were assimilated into the CALMET model with a radius of influence of 3 km to improve the correlation of the model prediction with actual surface wind measurements.

The CALMET meteorological model takes into account the different mixing height and stability classes. The frequency of the various stability classes is provided in Figure D1. The most common stability classes in which inversion layers occur is class F, when the mixing height is less than 100 m. As shown in D1 this is the most common condition being predicted in the model.

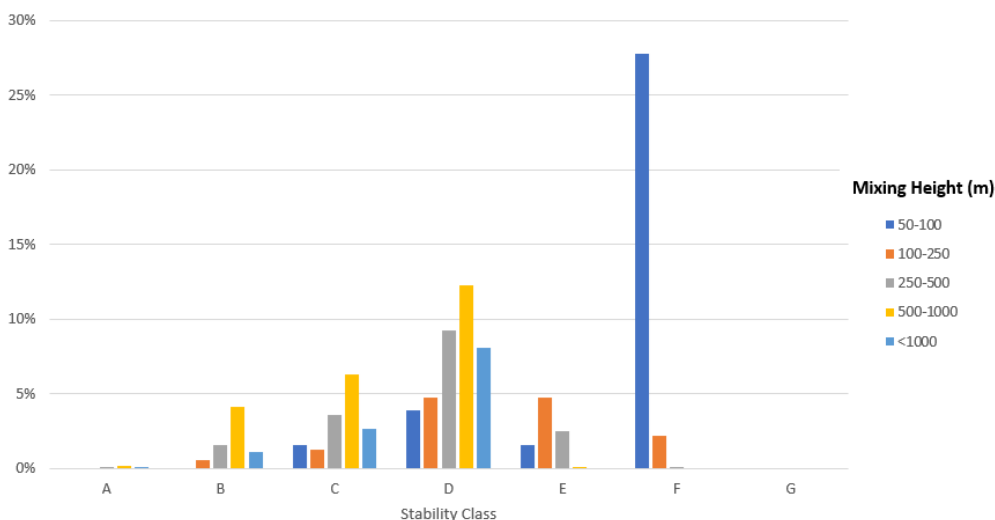


Figure D1: Stability Classes and Mixing Heights

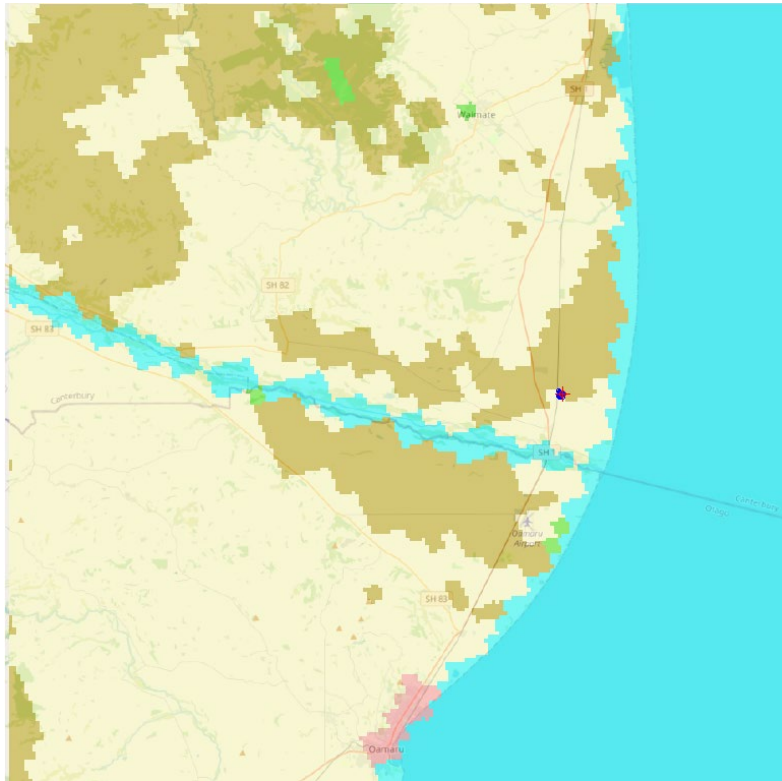


Figure D2: CALPUFF Land Use

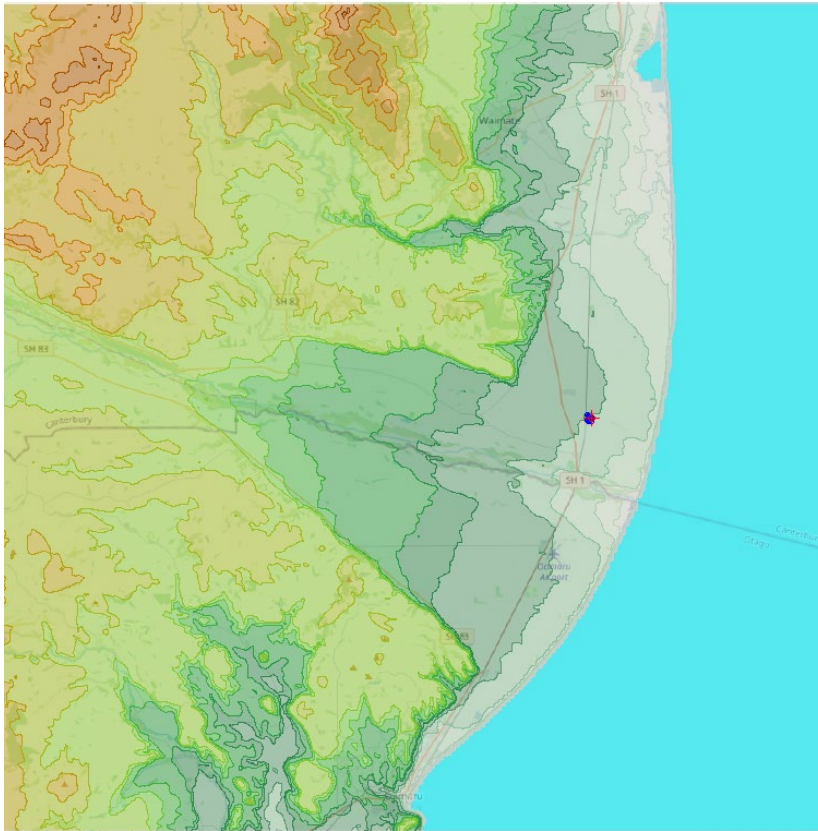


Figure D3: CALPUFF Terrain Heights



In China there is a public database that contains real time monitoring information for all Energy from Waste plants<sup>37</sup>. PDP has reviewed data for plants operated by CNTY and has extracted real time monitoring data for two plants which operate to similar emission standards that are proposed for this Site.

To account for fluctuations in plant operation, PDP has taken data from multiple times/days and taken the average. The results are provided in Table E1.

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<sup>37</sup> <https://ljgk.envsc.cn/index.html>

<b>Table E1: Instantaneous Emission Concentrations</b>									
<b>Shenzhen Tianying (One Discharge Monitoring Point) (mg/m<sup>3</sup>)</b>									
	11/11/2022		14/11/2022		15/11/2022		16/11/2022		<b>Plant Standard</b>
Particulate	0.95		0.85		0.86		0.85		<b>10</b>
NOx	41.06		48.91		47.05		41.81		<b>80</b>
SO <sub>2</sub>	2.5		1.41		1.42		1.65		<b>50</b>
HCl	3.43		2.06		1.82		2.10		<b>10</b>
CO	0.59		0.62		0.68		0.95		<b>50</b>
<b>Minquan Tianying (Two Discharge Monitoring Points) (mg/m<sup>3</sup>)</b>									
	11/11/2022		14/11/2022		15/11/2022		16/11/2022		<b>Plant Standard</b>
Particulate	1.43	2.15	1.31	1.93	1.47	2.4	1.35	2.31	<b>20</b>
NOx	97.3	96.99	101.98	99.64	102.38	102.91	100.97	102.41	<b>250</b>
SO <sub>2</sub>	31.23	36.65	28.53	33.11	18.3	30.18	19.9	30.39	<b>80</b>
HCl	5.23	1.57	6.5	2.23	8.61	3.7	8.95	5.38	<b>10</b>
CO	1.44	3.35	1.86	3.39	0.57	2.75	0.58	2.8	<b>80</b>

### Additional Shenzhen Testing Data

Additional testing data for the Shenzhen Plant was provided for 2022 with the flue gas testing results presented in Table E2.

Table E2: 2022 Flue Gas Testing Data – Shenzhen Plant (mg/m <sup>3</sup> )					
Contaminant	Standard	11 Feb	10 May	8 Aug	28 Aug
PM	10	1.0	ND	ND	4.2
SO <sub>2</sub>	50	1.9	ND	ND	ND
NO <sub>x</sub>	80	40	46	43	29
HCl	10	2.92	2.47	0.31	0.42
CO	50	0.7	ND	ND	ND

As shown in Table E2, the concentrations are well below the standard, with some results being below the limit of detection.

Flue gas heavy metal testing data has been undertaken monthly in 2022, with the results from April to November being provided. Table E3 outlines these results and indicates that the plant is operating well below the Chinese standard. The European standard value has been provided in brackets.

Table E3: 2022 Flue Gas Testing Heavy Metal Data – Shenzhen Plant (mg/m <sup>3</sup> )									
Contaminant	Chinese (EU) Standard	Apr	May	Jun	8 Jul	8 Aug	7 Sep	13 Oct	1 Nov
Hg and Compounds	0.05 (50)	ND	ND	0.0036	ND	ND	ND	ND	ND
Cd and Compounds	0.1 (0.05)	ND	ND	ND	ND	ND	ND	ND	ND
Pb and Compounds	1 (0.5)	0.0005	ND	ND	0.0004	0.0004	0.0004	0.0002	0.0002

Dioxin testing has also been conducted at this site with the results provided in Table E4. As with all the other testing results the data shows the site operating well below the design standard.

Table E4: June 2022 Flue Gas Dioxin Testing Data – Shenzhen Plant (ng-TEQ/m <sup>3</sup> )					
Contaminant	EU / Chinese Standard	Test 1	Test 2	Test 3	Average
Dioxin	0.1	0.0026	0.0018	0.0016	0.002





**Table F1: 1-hour Receptor Concentrations**

Contaminant	Receptor																
	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10	R11	R12	R13	R14	R15	R16	R17
Ammonia	2.5	3.3	2.4	1.7	1.9	4.8	2.8	2.3	2.1	3.9	3.1	2.3	2.9	3.0	1.8	0.7	0.09
Hydrogen Chloride	1.5	2.0	1.4	1.0	1.2	2.9	1.7	1.4	1.3	2.3	1.9	1.4	1.7	1.8	1.1	0.4	0.06
Hydrogen Fluoride	0.3	0.3	0.2	0.2	0.2	0.5	0.3	0.2	0.2	0.4	0.3	0.2	0.3	0.3	0.2	0.07	0.009
Mercury	0.005	0.006	0.005	0.003	0.004	0.009	0.005	0.004	0.004	0.008	0.004	0.004	0.005	0.006	0.003	0.001	0.0002
Metals <sup>38</sup>	0.01	0.02	0.01	0.01	0.01	0.02	0.01	0.01	0.01	0.02	0.02	0.01	0.01	0.01	0.01	0.003	4.4 x 10 <sup>-4</sup>
Arsenic	0.002	0.003	0.002	0.002	0.002	0.005	0.003	2.3 x 10 <sup>-3</sup>	2.1 x 10 <sup>-3</sup>	3.9 x 10 <sup>-3</sup>	3.1 x 10 <sup>-3</sup>	2.3 x 10 <sup>-3</sup>	2.9 x 10 <sup>-3</sup>	2.9 x 10 <sup>-3</sup>	1.8 x 10 <sup>-3</sup>	6.8 x 10 <sup>-4</sup>	9.5 x 10 <sup>-5</sup>
Thallium	5.0 x 10 <sup>-4</sup>	6.6 x 10 <sup>-4</sup>	4.8 x 10 <sup>-4</sup>	3.5 x 10 <sup>-4</sup>	3.9 x 10 <sup>-4</sup>	9.6 x 10 <sup>-4</sup>	5.6 x 10 <sup>-4</sup>	4.6 x 10 <sup>-4</sup>	4.2 x 10 <sup>-4</sup>	7.8 x 10 <sup>-4</sup>	6.3 x 10 <sup>-4</sup>	4.6 x 10 <sup>-4</sup>	5.8 x 10 <sup>-4</sup>	5.9 x 10 <sup>-4</sup>	3.5 x 10 <sup>-4</sup>	1.4 x 10 <sup>-4</sup>	1.9 x 10 <sup>-5</sup>
Trimethyl-Benzene	2.5	3.3	2.4	1.7	1.9	4.8	2.8	2.3	2.1	3.9	3.1	2.3	2.9	3.0	1.8	0.7	0.09

**Table F2: 3 Monthly Receptor Concentrations**

Contaminant	Receptor																
	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10	R11	R12	R13	R14	R15	R16	R17
Lead	6.5 x 10 <sup>-5</sup>	2.5 x 10 <sup>-4</sup>	1.9 x 10 <sup>-4</sup>	1.3 x 10 <sup>-4</sup>	9.5 x 10 <sup>-5</sup>	1.4 x 10 <sup>-4</sup>	1.6 x 10 <sup>-4</sup>	9.8 x 10 <sup>-5</sup>	1.6 x 10 <sup>-4</sup>	2.8 x 10 <sup>-4</sup>	2.2 x 10 <sup>-4</sup>	2.1 x 10 <sup>-4</sup>	6.8 x 10 <sup>-5</sup>	5.9 x 10 <sup>-5</sup>	3.2 x 10 <sup>-5</sup>	4.3 x 10 <sup>-5</sup>	3.6 x 10 <sup>-6</sup>

<sup>38</sup> All Metals have been assessed as 1% of PM concentrations except for Arsenic and Thallium.

**Table F3: Annual Receptor Concentrations**

Contaminant	Receptor																
	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10	R11	R12	R13	R14	R15	R16	R17
Ammonia	0.006	0.04	0.03	0.02	0.02	0.02	0.02	0.01	0.02	0.05	0.04	0.03	0.008	0.007	0.004	0.009	0.001
Dioxins	3.3 x10 <sup>-11</sup>	2.2 x10 <sup>-10</sup>	1.9 x10 <sup>-10</sup>	1.4 x10 <sup>-10</sup>	8.7 x10 <sup>-11</sup>	1.2 x10 <sup>-10</sup>	1.1 x10 <sup>-10</sup>	7.8 x10 <sup>-11</sup>	1.1 x10 <sup>-10</sup>	2.7 x10 <sup>-10</sup>	2.2 x10 <sup>-10</sup>	1.5 x10 <sup>-10</sup>	5.2 x10 <sup>-11</sup>	3.8 x10 <sup>-11</sup>	1.8 x10 <sup>-11</sup>	4.6 x10 <sup>-11</sup>	2.4 x10 <sup>-12</sup>
Hydrogen Chloride	0.003	0.02	0.02	0.01	0.01	0.01	0.01	0.008	0.01	0.03	0.02	0.02	0.006	0.004	0.002	0.005	0.0003
Mercury	1.1 x 10 <sup>-5</sup>	7.1 x 10 <sup>-5</sup>	6.2 x 10 <sup>-5</sup>	4.5 x 10 <sup>-5</sup>	2.9 x 10 <sup>-5</sup>	4.0 x 10 <sup>-5</sup>	3.5 x 10 <sup>-5</sup>	2.6 x 10 <sup>-5</sup>	3.5 x 10 <sup>-5</sup>	9.0 x 10 <sup>-5</sup>	7.1 x 10 <sup>-5</sup>	4.9 x 10 <sup>-5</sup>	1.7 x 10 <sup>-5</sup>	1.2 x 10 <sup>-5</sup>	5.9 x 10 <sup>-6</sup>	1.5 x 10 <sup>-5</sup>	8.0 x 10 <sup>-7</sup>
Metals <sup>39</sup>	2.7 x 10 <sup>-5</sup>	1.8 x 10 <sup>-4</sup>	1.6 x 10 <sup>-4</sup>	1.1 x 10 <sup>-4</sup>	7.3 x 10 <sup>-5</sup>	1.0 x 10 <sup>-4</sup>	9.0 x 10 <sup>-5</sup>	6.5 x 10 <sup>-5</sup>	8.8 x 10 <sup>-5</sup>	2.3 x 10 <sup>-4</sup>	1.8 x 10 <sup>-4</sup>	1.2 x 10 <sup>-4</sup>	4.3 x 10 <sup>-5</sup>	3.1 x 10 <sup>-5</sup>	1.5 x 10 <sup>-5</sup>	3.8 x 10 <sup>-5</sup>	2.0 x 10 <sup>-6</sup>
Arsenic	5.8 x 10 <sup>-6</sup>	3.6 x 10 <sup>-5</sup>	3.1 x 10 <sup>-5</sup>	2.3 x 10 <sup>-5</sup>	1.5 x 10 <sup>-5</sup>	2.1 x 10 <sup>-5</sup>	1.8 x 10 <sup>-5</sup>	1.3 x 10 <sup>-5</sup>	1.8 x 10 <sup>-5</sup>	4.6 x 10 <sup>-5</sup>	2.7 x 10 <sup>-5</sup>	2.5 x 10 <sup>-5</sup>	9.2 x 10 <sup>-6</sup>	6.7 x 10 <sup>-6</sup>	3.6 x 10 <sup>-6</sup>	8.9 x 10 <sup>-6</sup>	5.1 x 10 <sup>-7</sup>
Thallium	1.2 x 10 <sup>-6</sup>	7.2 x 10 <sup>-6</sup>	6.4 x 10 <sup>-6</sup>	4.7 x 10 <sup>-6</sup>	3.0 x 10 <sup>-6</sup>	4.2 x 10 <sup>-6</sup>	3.7 x 10 <sup>-6</sup>	2.7 x 10 <sup>-6</sup>	3.7 x 10 <sup>-6</sup>	9.3 x 10 <sup>-6</sup>	7.4 x 10 <sup>-6</sup>	5.1 x 10 <sup>-6</sup>	1.8 x 10 <sup>-6</sup>	1.3 x 10 <sup>-6</sup>	7.2 x 10 <sup>-7</sup>	1.8 x 10 <sup>-6</sup>	1.1 x 10 <sup>-7</sup>
Benzene	0.006	0.04	0.03	0.02	0.02	0.02	0.02	0.01	0.02	0.05	0.04	0.03	0.009	0.007	0.004	0.009	0.001
Xylene	0.006	0.04	0.03	0.02	0.02	0.02	0.02	0.01	0.02	0.05	0.04	0.03	0.009	0.007	0.004	0.009	0.001
Toulene	0.006	0.04	0.03	0.02	0.02	0.02	0.02	0.01	0.02	0.05	0.04	0.03	0.009	0.007	0.004	0.009	0.001
Trimethyl-Benzene	0.006	0.04	0.03	0.02	0.02	0.02	0.02	0.01	0.02	0.05	0.04	0.03	0.009	0.007	0.004	0.009	0.001
Hydrogen Fluoride	0.001	0.004	0.003	0.002	0.002	0.002	0.002	0.001	1.85E-03	0.005	0.004	0.003	0.001	0.001	0.000	0.001	0.0001

<sup>39</sup> All Metals have been assessed as 1% of PM concentrations except for Arsenic and Thallium.



<b>Table G1: Predicted Dust Deposition Concentrations</b>			
<b>Receptor</b>	<b>Predicted GLC (g/m<sup>2</sup>/30 days)</b>		
	<b>Wet Dust Concentration</b>	<b>Dry Dust Concentration</b>	<b>Total</b>
Maximum Off-site	0.09	8.3 x 10 <sup>-5</sup>	0.09
R1	0.004	5.2 x 10 <sup>-6</sup>	0.004
R2	9.5 x 10 <sup>-4</sup>	2.7 x 10 <sup>-5</sup>	9.8E-04
R3	0.005	2.3 x 10 <sup>-5</sup>	0.005
R4	0.001	1.4 x 10 <sup>-5</sup>	0.001
R5	1.3 x 10 <sup>-4</sup>	8.4 x 10 <sup>-6</sup>	1.3 x 10 <sup>-4</sup>
R6	1.6 x 10 <sup>-4</sup>	2.6 x 10 <sup>-5</sup>	1.9 x 10 <sup>-4</sup>
R7	2.5 x 10 <sup>-4</sup>	2.1 x 10 <sup>-5</sup>	2.7 x 10 <sup>-4</sup>
R8	4.5 x 10 <sup>-4</sup>	7.6 x 10 <sup>-6</sup>	4.6 x 10 <sup>-4</sup>
R9	2.0 x 10 <sup>-4</sup>	3.1 x 10 <sup>-5</sup>	2.3 x 10 <sup>-4</sup>
R10	7.2 x 10 <sup>-4</sup>	2.9 x 10 <sup>-5</sup>	7.5 x 10 <sup>-4</sup>
R11	7.4 x 10 <sup>-4</sup>	2.6 x 10 <sup>-5</sup>	7.7 x 10 <sup>-4</sup>
R12	0.004	1.8 x 10 <sup>-5</sup>	0.004
R13	0.001	4.3 x 10 <sup>-6</sup>	0.001
R14	0.002	3.9 x 10 <sup>-6</sup>	0.002
R15 – Waimate	1.6 x 10 <sup>-4</sup>	1.7 x 10 <sup>-6</sup>	1.6 x 10 <sup>-4</sup>
R16 – Oamaru	2.0 x 10 <sup>-4</sup>	3.6 x 10 <sup>-6</sup>	2.1 x 10 <sup>-4</sup>
R17 - Duntroon	5.0 x 10 <sup>-5</sup>	2.3 x 10 <sup>-7</sup>	5.0 x 10 <sup>-5</sup>
<b>Standard</b>	<b>4</b>		

Table G2: Predicted Dust Deposition Concentrations			
Receptor	Predicted GLC (g/m <sup>2</sup> /year)		
	Wet Dust Concentration	Dry Dust Concentration	Total
Maximum Off-site	0.164	1.96 x 10 <sup>-4</sup>	0.164
R1	0.013	1.29 x 10 <sup>-5</sup>	0.013
R2	0.003	1.16 x 10 <sup>-4</sup>	0.004
R3	0.011	9.43 x 10 <sup>-5</sup>	0.011
R4	0.003	6.42 x 10 <sup>-5</sup>	0.003
R5	3.40 x 10 <sup>-4</sup>	3.68 x 10 <sup>-5</sup>	3.76 x 10 <sup>-4</sup>
R6	5.03 x 10 <sup>-4</sup>	9.72 x 10 <sup>-5</sup>	6.00 x 10 <sup>-4</sup>
R7	8.83 x 10 <sup>-4</sup>	5.83 x 10 <sup>-5</sup>	9.42 x 10 <sup>-4</sup>
R8	0.001	3.28 x 10 <sup>-5</sup>	0.001
R9	5.46 x 10 <sup>-4</sup>	8.00 x 10 <sup>-5</sup>	6.26 x 10 <sup>-4</sup>
R10	0.003	1.43 x 10 <sup>-4</sup>	0.003
R11	0.004	1.17 x 10 <sup>-4</sup>	0.004
R12	0.010	8.82 x 10 <sup>-5</sup>	0.010
R13	0.005	1.95 x 10 <sup>-5</sup>	0.005
R14	0.004	1.15 x 10 <sup>-5</sup>	0.004
R15 – Waimate	9.31 x 10 <sup>-4</sup>	6.52 x 10 <sup>-6</sup>	9.38 x 10 <sup>-4</sup>
R16 – Oamaru	7.14 x 10 <sup>-4</sup>	1.88 x 10 <sup>-5</sup>	7.33 x 10 <sup>-4</sup>
R17 - Duntroon	1.45 x 10 <sup>-4</sup>	8.50 x 10 <sup>-7</sup>	1.46 x 10 <sup>-4</sup>